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United States  
Department of  
Agriculture  
Agricultural  
Research  
Service

# Crop Protection Research

## 1981 Annual Report

APR 3 '85

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## FOREWORD

### Crop Protection

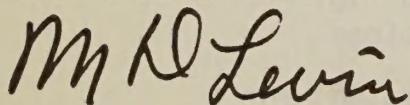
Research included in this report is conducted to improve crop protection technology including biological and chemical methods to control insects, diseases, weeds, nematodes, and other pests while at the same time retaining or improving the quality of our environment.

New multidisciplinary concepts for pest management and control include the development and integrated use of conventional pesticides; behavior control chemicals such as pheromones and attractants; genetic techniques, parasites, predators, pathogens, and weed-feeding insects; disease and insect resistance in host plants and plant growth chemicals.

The research workers in the Agricultural Research Service (ARS) publish the results of their investigations in the open literature as quickly as sound scientific judgment warrants. This is an administrative report to provide for those interested in the results of this work a brief overview of the scope of the activities and examples of recent findings, some of which still have not been released by publication. No attempt is made at completeness.

This report outlines the crop protection research for which the Crop Sciences Staff is responsible and provides a brief description of recent accomplishments at the various locations throughout the United States. The report is organized by ARS National Research Programs, each of which describes a separate subject matter area. The ARS National Research Programs are subdivided into Technological Objectives which more specifically describe the objectives of each area of research.

Readers who have comments or inquiries are invited to contact either the National Program Staff or, more appropriately, scientists at the locations where the research is conducted.



M. D. LEVIN  
Chief  
Crop Sciences Staff



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## SUMMARY

Crop protection research is an integral part of the total research program in the Science and Education Administration. The research is described under eight National Research Programs (NRP) and three Special Research Programs (SRP). A brief summary of each NRP and SRP is provided in the front of this volume. More detailed reports for each NRP and SRP follow with selected examples of progress and publications.

### NRP 20220 Insect Control - Horticultural Crops

The mission of the National Research Program of Insect Control in Horticultural Crops is to provide through research new or improved methods which may be used to reduce the losses caused by insects and mites. The ultimate goal of this program is to develop integrated systems for control of insects of horticultural crops for local or area-wide use which are compatible and complementary and based upon effective use of all appropriate control technologies. Providing new and innovative technology for protecting horticultural crops from insects and mites is an essential component for the production of reliable and safe supplies of these crops that are reasonable in cost to the consumer and yet profitable to the farmer. This emerging technology will not jeopardize the proper conservation of our natural resources, will help to provide an ample supply of food for the Nation, and will increase the potential of export to other countries.

This National Research Program is conducted in concert with the several State Agricultural Experiment Stations and is responsive to the research needs identified by industry. The program is currently conducted at 15 locations by a total of 55 scientists operating on a total budget of about \$8 million. The results of this research we reported in scientific journals at a rate of over 100 publications per year.

Outstanding accomplishments during the past year include the following:

The Citrus Insects Laboratory, Weslaco, TX, and the Citrus Insects Research Unit, Orlando, FL, both won the USDA's Distinguished Service Award for defeating the citrus blackfly in the U.S.

The Tropical Fruit and Vegetable Research Laboratory, Honolulu, HI, has supplied over one billion sterile medflies for use in the California eradication program.

Immediately following the May 18 eruption of Mt. St. Helens, scientists at the Yakima Agricultural Research Laboratory began a series of experiments which have determined the effects of volcanic ash on fruit and vegetable production and the effects of ash on both beneficial and harmful insects.

In order to provide on-site research support for the Mediterranean fruit fly control program in Central America a satellite laboratory of our Honolulu facility has been established in Guatemala City, Guatemala.

Current and future plans call for increased effort in several areas including the following: (1) New and improved chemical control methods using safer yet effective insecticides that are selectively toxic to target pests will be developed. (2) A number of biological control methods will be improved and

evolved by manipulating native populations or by introducing biological control agents. (3) The identification and production of sex pheromones, chemical attractants and repellents for survey detection and monitoring of insect control will be continued. (4) New thrusts including male-only rearing techniques, isoenzyme analysis and other autocidal procedures will be pursued. (5) The development of horticultural crops resistant to insect attack will be emphasized especially in the area of tree fruits. Such studies will include the gathering of basic information on the occurrence, distribution, ecology, life history, host range, physiology, and economic thresholds of pests in order to develop new methods of control or make those existing controls more effective.

#### NRP 20230 Cotton and Tobacco Insects

With this research new and improved practices are developed for control of insects and mites attacking cotton and tobacco. Practices may be used alone or in integrated systems on a farm-by-farm or area-wide basis, but those methods that in particular apply to use in area-wide management programs have been emphasized. Control technologies are being developed with genetic methods, attractants, parasites and predators, microbial agents, insect and plant growth regulators, insecticides, cultural practices, and resistant varieties. Survey methods, loss thresholds, and descriptive and predictive insect population models have also been studied to develop a basis for implementing various control technologies and integrating them into production systems.

Recent advances include: (1) development of a practical artificial diet for rearing lygus bugs; (2) design of controlled-release dispensers for pheromones of the bollworm and tobacco budworm; (3) in cooperation with private industry, development of an effective sprayable formulation of the pink bollworm pheromone; (4) application of simulation modeling and statistics to an estimation of success for the boll weevil trial eradication, with the probability exceeding 0.9983; (5) suppression of tobacco budworms by release of reared backcross sterile insects; (6) wide adoption of nectariless varieties by growers to reduce insect damage; and (7) use of computer models to predict insect populations in the western and southwestern states.

#### NRP 20240 Insect Control - Grains, Forages, Sugar Crops, and Oilseeds

The primary objective of this national research program is to develop new and improved control methods, tactics and strategies to reduce insect related losses of corn, small grains, sorghum, grass and legume forages, sugarbeets, sugarcane, soybeans, peanuts, sunflowers, and other field crops. This research is a part of the cooperative effort by Federal, State, and industry scientists to provide the knowledge needed to protect more than 300 million acres of field crops and one billion acres of grazing land from insect degradations. Multiple control components are developed and integrated into insect management systems.

Control approaches in which significant progress was reported in 1980 include biological control, host-plant resistance, cultural practices, and chemical control. Also, significant progress was reported in the development of insect attractants, the development of economic injury levels and monitoring methods for integrated management systems, information on biological and ecological studies of pests and beneficial insects, the use of radar to study insect

migration, and the development of information on the relationship between insects and insect vectored diseases.

Some of the significant accomplishments in host-plant resistance were the release of sweetcorn germplasm with resistance to the corn earworm; the release of two wheat varieties with resistance to the Hessian fly and barley yellow dwarf disease; the release of alfalfa varieties with resistance to the spotted alfalfa aphid and the alfalfa weevil, potato leafhopper, pea aphid and their diseases; the identification of blue grass germplasm with resistance to chinch bugs; sorghum germplasm with resistance to chinch bugs; alfalfa with resistance to blotch leaf miner, alfalfa with curculio resistance, and rice with rice water weevil resistance.

A few of the significant accomplishments in biological control included an increased understanding of how plant odors affect the host-finding or search behavior of pest insects and their parasites; the continued development of insect pathogens, such as a virus and a microsporidian for corn earworm and fall armyworm control, the use of parasites to control green stink bugs, the use of Trichogramma parasites to control the corn earworm and the fall armyworm, and the use of Nosema locustae to control grasshoppers.

Significant progress was also made in the development and use of sex attractants in management programs for the corn earworm, corn rootworms, the cranberry girdler, and the lesser corn stalk borer.

Other research in support of IPM systems included economic injury levels for greenbugs on sorghum, the sugarcane borer in sugarcane, the fall armyworm in peanuts and Heliothis spp. on soybeans. Population monitoring methods were developed for the black cutworm, the sugarbeet root maggot, and wireworms.

#### NRP 20250 Basic/Noncommodity Research for Insect Control

Substantial advances were made in insect physiology. A few highlights are as follows:

- . The fat body of the last larval instar of wax moths synthesizes and exports large quantities of storage protein. Receptor sites on cell membranes recognize glycosyl residues on the protein and facilitate the transport of protein molecules through cell membranes.
- . A unique self perpetuating cell line has been derived from cabbage looper imaginal discs. Since this cell line responds to the actions of developmental hormones, it will be a significant tool in hormonal mode-of-action and developmental studies.
- . Makisterone A was found to be the principal molting hormone in the weed bud.
- . The chitin synthesis inhibitor, diflubenzuron, synergizes the action of juvenile hormone in the boll weevil by 70-100 fold. Diflubenzuron inhibits the enzymatic degradation of juvenile hormone I.
- . A hormone produced by house fly ovaries induces the synthesis of the sex pheromone.

Substantial progress was made in identifying pheromones. The pheromone of the Western corn rootworm was found to be 8-methyl-2-decanol propanoate. Pheromones were identified for the beet armyworm, Asian corn borer, artichoke plume moth, Heliothis subflexa, cranberry fireworm and citrus cutworm. Other important accomplishments include:

- Hybrids of Heliothis subflexa and Heliothis virescens can be identified by biochemical analysis of mitochondrial DNA.
- The geographic areas of origin were determined for introduced medflies by isozyme analysis.
- Fifty-two new candidate chemicals for insect control were submitted to SEA/AR by industrial laboratories.
- A voltametric detector was devised which quantitates nanogram quantities of pesticides.
- Three new compounds were identified as promising fumigants for fruits and cereal products.

#### NRP 20260 Biological Agents for Pest Control

Research in NRP 20260 is concerned with (1) the control of agricultural pests by the use of natural enemies and (2) taxonomic research related to arthropods. The more than 67 SY's in this program are spread among 20 locations in 10 States and four overseas research laboratories. Of these, 25 SY's are devoted to taxonomic research at the Systematic Entomology Laboratory in Beltsville; the balance of the research program is directed to the many facets of biological control.

There is considerable emphasis on the development of in vitro rearing techniques as a means to increase efficiency and lower cost of rearing natural enemies and their hosts and on basic studies related to cell and tissue culture.

Recognition of the potential of native as well as exotic plant pathogens for weed control has resulted in the demonstrated use of these organisms for weed control. Insect pathogens have been emphasized in new fields of research, which include intensive study of organisms such as spiroplasmas, non-inclusive viruses, new and improved strains of bacteria, the action of baculovirus, and the development of serum-free media for insect-virus production. Experiments with protozoans and fungi may allow these pathogens to be used for control of rangeland and forest insect pests.

The introduction of exotic natural enemies for weed and arthropod control continues to be a mainstay of the program. Improved overseas facilities are planned to meet increased domestic demands for beneficial organisms. Research and cooperation in this NRP are national and international in scope. This includes a considerable amount of cooperation within the framework of ARS and with other Federal, State, and academic organizations throughout the U.S. and with similar agencies of other nations. Increased emphasis in integrated pest management (IPM) has, and will, result in greater interaction with Federal organizations such as APHIS, OICD, USAID, and the FS. International cooperation

has steadily increased with the U.S.S.R., P.R.C., and third-world countries in Africa and the East through the exchange of personnel, information, specimens, and cooperative bilateral research projects.

Future research within this NRP will include the improvement of and application of criteria for selecting target organisms for weed and insect control projects; massive inundative and augmentative release projects; the greater use of plant pathogens for weed control; refinement and use of sophisticated rearing techniques to support the release programs; support for the basic and applied research with pathogens; and new fields of exploration and study for the overseas laboratories and the associated domestic receiving stations. ARS must increase its competence in taxonomy to meet the needs of research scientists throughout the country as well as its international commitments. More and more demands are being made on biological control as part of numerous IPM programs; these demands require an increased effort to obtain new organisms for release and the efficient use of our native beneficial agents.

NRP 20270 Crop Disease Control and Noncommodity Research on Plant Pathogens and Nematodes

Research reported herein reveals a growing recognition of the importance of crop protection and an increased awareness of the need to decrease crop losses caused by plant pathogens and nematodes. Significant progress has been made, particularly in the area of improved combinations of approaches involving cultural practices, pesticides, resistant varieties, and biological control. For example, damping-off and blight diseases of beans caused by soil fungi were reduced by deep plowing, use of antagonistic biocontrol agents, and the use of small amounts of seed-treatment chemicals. We also recognize the growing importance of evaluating and selecting germplasm with resistance or tolerance to diseases and nematodes. The identification of a potential root-stock for pistachio to provide tolerance to *Verticillium* wilt is an example. Research studies on nematodes are continuing with the aim of identifying weak points in the life cycle, population damage thresholds, and better methods of control. Maximum protection against nematodes is not always the most cost effective management practices; and research at Tifton, Georgia, highlights the necessity to involve economic aspects as our research is conducted. Significant contributions were made in the taxonomy of plant pathogens and nematodes which is an essential part in the evaluation of resistant germplasm. Studies will continue in the areas of basic research aimed at extending our knowledge of plant pathogens, nematodes, and their interactions with hosts.

NRP 20280: Weed Control Technology for Protecting Crops, Grazing Lands, Aquatic Sites, and Noncropland

In 1980 progress was reported in more than 150 scientific publications. This included developing an understanding of the life cycle of weeds, such as germination of seeds, growth, reproduction, allelopathic relationships, and competitiveness with crops in relation to development of weed control technology. The discovery of allelopathic effects and the effects of naturally occurring secondary chemicals in weeds and crops provides new approaches for developing weed control technology. More than 60 new chemicals were evaluated for their weed control effectiveness and safety in about 70 crops, aquatic sites, and rangelands. Controlled-release technology for herbicides was improved in 1980. Progress in understanding the penetration,

absorption, translocation, sites and mechanisms of selective action, and metabolic fate in plants, soil, water, and the environment has increased the performance efficiency and safety of herbicides.

Several plant pathogens are being developed for weed control and some are now ready for widespread use in rice, soybeans, and other crops. More than 20 species of insects are being developed for weed control in crops, rangelands, and aquatic sites. Unique herbicide application equipment, such as the rope wick applicator, recirculating sprayer, endless belt applicator, and roller wipers, that prevents drift and reduces volatility and applies herbicides to weeds in crops without getting the herbicides on crops or soils is being developed and several designs are in widespread use. Outstanding progress was made in developing new weed control components technology that will increase the effectiveness and safety of integrated weed management and pest management systems. The development of improved and new chemical weed control practices and their use in integrated weed and vegetation management systems is enhancing revolutionary advances in reduced tillage, minimum tillage, no-tillage and conservation tillage crop production systems. These systems are increasing crop yields, lowering production costs, reducing the use of energy, increasing water use efficiency, and reducing soil erosion.

The research in NRP 20280 develops technology for increasing and improving efficiency of food, feed, and fiber production. This NRP supports the research, extension, and education mission of Science and Education (S&E) USDA; the provisions of the Federal Noxious Weed Act of 1974 (FNWA) - administered by the Animal and Plant Health Inspection Service (APHIS); Federal Seed Act - administered by the Agricultural Marketing Service (AMS); and the operational programs of the Soil Conservation Service (SCS), Rural Electrification Administration (REA), Forest Service (FS), Federal Grain Inspection Service (FIGS), and the Agricultural Stabilization and Commodity Service (ASCS) of the U.S. Department of Agriculture. It also aids in meeting the pesticide registration requirements of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), administered by the U.S. Environmental Protection Agency (EPA); and operational programs of the Tennessee Valley Authority (TVA); Food and Drug Administration (FDA); Drug Enforcement Administration (DEA); Department of Defense (DOD); and five agencies of the U.S. Department of the Interior; and other Federal agencies.

NRP 20290: Agricultural Chemicals Technology for  
Crop Protection and Modification

Progress in 1980 was reported in 50 scientific publications. More than 100 new chemicals were evaluated for their effectiveness and safety as herbicides, fungicides, nematicides, insecticides, and plant growth modifiers. Improved methods were developed for the synthesis of strigol, the stimulator of witchweed seed germination. The larger quantities, up to one pound, expected to be available in 1982 will facilitate field evaluation research to develop improved witchweed control technology and to determine the effects of strigol on the germination of other weed seeds.

Outstanding progress was made in improving techniques and systems for the discovery, evaluation, and development of new, improved, selective, biodegradable, and safe pesticides and plant growth modifiers. Progress was also made in developing a basic understanding of their penetration, absorption, translocation, sites of action, mechanisms of action, role of membranes in herbicidal action, and their metabolic fate and effects in plants, soil, water, and other components of the environment. Improved application equipment and controlled release formulations of agricultural chemicals were developed that will increase

their performance effectiveness and safety, reduce the need for excessive use, and reduce the risks to nontarget organisms and other components in the environment.

Basic research to determine how herbicides kill plants resulted in the development of new chemicals which reduce high-temperature damage to crops, reduce cold hardiness of weeds making them easier to control, eliminate rancidity in oils, change fatty acid composition of oil seed, and change insect lipids making insects more susceptible to control. This discovery will also provide plant breeders with screening techniques that will aid in the development of crops with greater heat or cold hardiness. Basic research on surfactants, protectants, and other additives in agricultural chemical formulations is providing fundamental information that can be used to optimize residual activity, penetration, absorption, and translocation, stability in formulations, and aid in better understanding the metabolism and fate of agricultural chemicals.

The research in NRP 20290 develops technology for increasing and improving the efficiency of food, feed, and fiber production. This NRP supports the research, extension and education programs of the Science and Education (S&E) USDA; the Federal Noxious Weed Act of 1974 (FNWA)--administered by the Animal and Plant Health Inspection Service (APHIS); and the Federal Seed Act--administered by the Agricultural Marketing Service (AMS); and the operational programs of other agencies of the U.S. Department of Agriculture. It also aids in meeting the pesticide registration requirements of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), administered by the U.S. Environmental Protection Agency (EPA); and the operational programs of the Tennessee Valley Authority (TVA); Food and Drug Administration (FDA); Drug Enforcement Administration (DEA); Department of Defense (DOD); five agencies of the U.S. Department of the Interior (USDI); and other Federal agencies.

#### NRP 20300 Pest Control Equipment and Methods

This program is addressed to solutions of physical problems involved in the control of important agricultural pests, and in development and testing of improved equipment needed for pest control. While the work is predominately engineering in nature, every project involves a high degree of cooperation with entomologists, weed scientists or chemists. The effort in this program is nearly equally divided among improved equipment for application of chemical pesticides, equipment for distribution of biological control materials and equipment and methods to facilitate practical pest management systems.

Particular progress was made this year in development and testing of sprayers which greatly increase the precision and control of pesticide usage. These sprayers meter pesticide concentrate into the water diluent immediately ahead of the spray nozzles at a rate proportional to travel speed, eliminating tank mix of pesticides and eliminating variation of application rate caused by variations in speed. The sprayer built for orchard use also completely surrounds the tree, to eliminate blow-through of spray.

Another area of progress was a new method of dissemination of parasitic wasps from aircraft, and new equipment for distribution of sterilized insects from ground vehicles in small fields.

Finally, a computer was developed which accurately predicts population of cotton bollworm, based upon data from early season population and subsequent weather. This program is being adopted on a large scale by one State Extension Service and is being accepted as a useful tool for IPM.

SRP      Integrated Pest Management Systems

This SRP focuses on the systems approach to integrating advanced proven technology into more cost effective, environmentally acceptable, and energy conserving pest management. This SRP was established to: (1) strengthen coordination of IPM systems research conducted in SEA/AR, (2) further increase use of the systems approach in pest management research, and (3) provide a more viable point of contact for U.S., foreign, and international organizations interested in SEA/AR research on IPM systems.

The SRP encourages cooperation not only with ESCS, APHIS, Extension, and Universities, but also private industry and NASA, NOAA, DOD, etc. Research results and knowledge applicable to IPM systems include pest biology and ecology, individual control components, models of commodity growth and pest population changes, electronic technology (computers, electronic pest detection methods, meteorological survey systems, aircraft and satellite data acquisition methods, etc.), economics, and systems research.

The Administrator of SEA/AR has established an annual allocation of \$1.1 million to fund this Program. Now in its first year, the Program consists of seven multidisciplinary projects each of 3-5 years duration. Each project is described herein.

SRP      Minor Use Pesticides

The mission of this program is to assure availability of pesticides for minor and special uses by the agricultural community to provide a continuation of crop and livestock production technology for production, storage, distribution, and marketing of food, feed, seed, and fiber. Federal scientists cooperated with State scientists to develop data leading toward registration of pesticide use patterns on 101 food requests and 499 ornamental requests in 1979.

SRP      Pilot Testing of Alternative Methods of Pest Control

The Administrator of SEA/AR has established a rotating discretionary fund of roughly \$1.6 million to support a developmental research program on alternative methods of pest control. The purpose of the fund is to enable scientists to conduct the developmental research needed to determine whether an emerging or potential pest control technology is either technically feasible (Category I) or technically and economically feasible (Category II) for implementation by the private or public sectors. Thus, the primary intent of the Program is strongly to develop potential alternatives to the sole reliance on broad spectrum pesticides. The funds are not to be used to shore up ongoing base programs.

Most pilot research projects are conducted with a strong inhouse component, and this is particularly true if the project will have to be followed with additional research. All projects involve developmental research on alternatives to sole reliance on broad spectrum chemical pesticides for managing insects, nematodes, weeds, and plant pathogens which cause losses during

production, and in postharvest processing and handling. However, proposals are not included in this program if they focus on control methods for other classes of pests such as vertebrates and microorganisms which cause animal or human diseases. The use of broad spectrum pesticides is included in projects if appropriately integrated with alternative control methods. The status of 29 projects is described.



## National Research Program 20220

### INSECT CONTROL - HORTICULTURAL CROPS

**Technological Objective:** New and improved methods to reduce losses caused by insects and mites to fruits, vegetables, nut trees, and nursery stock.

This National Research Program is composed of seven subelements which have as their collective objective to provide through research new or improved methods which may be used to reduce the losses to horticultural crops caused by insects and mites. The program subelements are identified as the control of insect pests of citrus, tropical and subtropical fruit, pome fruit, stone and small fruit, tree nuts, vegetables, shade trees, and nursery, ornamental, and other horticultural crops. Providing technology for protecting horticultural crops from insects and mites is an essential component for the production of steady, reliable, and safe supplies of these crops that are reasonable in cost to the consumer, yet profitable to the farmer.

NPS Contact: M. L. Cleveland

#### Research Locations:

Riverside, California  
Miami, Florida  
Orlando, Florida  
Byron, Georgia  
Hilo, Hawaii  
Honolulu, Hawaii  
Kimberly, Idaho  
Vincennes, Indiana  
West Lafayette, Indiana  
Beltsville, Maryland  
Wooster, Ohio  
Charleston, South Carolina  
Brownwood, Texas  
Weslaco, Texas  
Yakima, Washington  
Kearneysville, West Virginia

#### Examples of Recent Progress

The melon aphid, *Aphis gossypii*, shown to efficiently transmit severe "seedling yellows" strains of the lethal tristeza disease of citrus - Riverside, California. For decades, the melon aphid has been the only vector of citrus tristeza virus in California. Recently, it was also found to efficiently transmit severe "seedling yellows" strain of tristeza. These diseases were found in commercial orchards in two southern California counties. Because the melon aphid is widespread in California and because tristeza has been known to

kill entire orchards, a potentially disastrous situation exists in California citriculture.

The aphid, Aphis citricola, transmits at least one strain of tristeza - Riverside, California. A. citricola is the most common aphid in many California citrus districts and because it was shown to transmit a mild strain of tristeza. It is hoped that the aphid will disseminate the mild strain, thus offering cross-protection to citrus from the most severe strains.

Seeds from three muskmelon populations with various combinations of resistance to pest agents made available to plant breeders and seed producers - Riverside, California. Three resistant muskmelon lines released were: (1) an aphid-resistant melon for home gardeners and local consumption; (2) a melon that is resistant to aphids and powdery mildew and adapted to desert production and shipping; (3) an aphid- and wilt-resistant line adapted to desert culture and tolerant to sulfur dust. These new cantaloupe breeding lines may aid in the development of sound integrated pest management for cantaloupe production thereby reducing the use of pesticides.

Synthesis of pheromones for the citrus mealybug and citrus cutworm simplify detection, survey, monitoring and control - Riverside, California. The pheromones of these insects were collected from live virgin females and analyzed by spectrographic means to determine their identity. The use of these pheromones in the field may help to measure densities of populations more precisely and aid in their control by increasing the efficiency of timing pesticide applications against them. These actions can minimize pesticide use, thereby reducing costs to the consumer and preserving a more natural environment.

Several chemicals show acaricidal activity against citrus rust mite in field tests - Orlando, Florida. Fenbutaton-oxide was equally effective against citrus rust mites when formulated as a 4EC and when formulated as a 50 WP. Oil at 1 gal/100 gal of water continued to show control equal to that of established acaricides.

Biological control of citrus blackfly remains effective in south Florida - Orlando, Florida. Biological control of citrus blackfly in south Florida appears to be a static situation. Citrus blackfly populations remained very light, and parasite populations maintained their presence and thus have kept citrus blackfly populations low.

Oviposition attractant isolated from larval cocoons of peachtree borer - Byron, Georgia. A chemo-attractant from larval cocoons of the peachtree borer has been isolated with silica gel chromatography. The acetone-soluble compound which attracts ovipositing females in a laboratory bioassay system, is also present in resin exudation and in bark of peach trees. It is anticipated that this attractant may be used alone or in combination with synthetic pheromones to suppress peach borer populations.

Control of peachtree borer through mass trapping shows promise in peaches - Byron, Georgia. Sex pheromone traps evaluated during the past two seasons have provided significantly better control of peachtree borer than have conventional insecticides. The use of pheromone traps to control peachtree borers should be attractive to peach growers with small acreages, because the combined cost of

constructing the traps and producing pheromone bait is seen to be competitive with the cost of the current recommended insecticide program.

A new pecan pest threatens Georgia pecans - Byron, Georgia. A new species of Phylloxera has been discovered in Georgia. Each year for the last 5 years it has increased in abundance on most of the major cultivars grown in Georgia. Infestations are frequently severe enough to require control measures.

Pecan aphids may play significant role in alternate bearing - Byron, Georgia. Laboratory studies on the foliar feeding aphids of pecan have shown that three species may be involved in alternate bearing. The most striking effect was on pecan seedling growth, including main stem and root size. The aphids also reduced leaflet chlorophyll content from 17 to 33% and total sugar and starch content of the roots from 67 to 73%.

Olfactory trap superior to visual trap for capturing Mediterranean fruit flies - Honolulu, Hawaii. Rebell's yellow visual traps, known to be very effective in capturing apple maggots and cherry fruit flies, were compared with Nadel, McPhail, and Jackson olfactory traps for efficiency in capturing Mediterranean fruit flies. The results of the 1 year study showed that all the olfactory traps were superior to the yellow visual trap. Among the traps tested, the Jackson trap was the best. These results show that medfly response to the olfactory attractant, Trimedlure, is superior to color.

The Mediterranean fruit fly and the oriental fruit fly coexist in some micro-niches in Hawaii - Honolulu, Hawaii. According to the literature the Mediterranean fruit fly is suppressed by the oriental fruit fly at lower elevations but the Mediterranean fruit fly (medfly) is more abundant at higher elevations. Our data show that the presence of hosts such as mock orange, Surinam cherry, and strawberry guava permits the medfly to coexist with the oriental fruit fly at lower elevations. Therefore, the composition of the host fruit complex determines the distribution of the medfly in residential and field locations. More research on the mechanism of medfly host selection can pay dividends in determining what the medfly may do when it is introduced into new areas such as the continental U.S.

California fruit and vegetable industry aided by fruit fly lab in Hawaii - Honolulu, Hawaii. The Tropical Fruit and Vegetable Research Laboratory mobilized quickly to ship sterilized medflies to California when two separate medfly outbreaks were reported. Since July 1980 the laboratory in Hawaii has been providing some 20 million sterile medflies per week for use in the California eradication program, first in the San Fernando Valley and continuing to the present time in Santa Clara County. These flies have been of consistent high quality in mating competitiveness and vigor and have provided a standard by which to measure the quality of sterile flies from other sources.

Technique developed for storing live insects - West Lafayette, Indiana. The supplies and labor required for continuous culture of insect colonies can be very expensive. New procedures have been developed for storing insects during periods when they are not needed for experimental purposes.

Sex pheromone found for insect pest of ornamentals - Beltsville, Maryland. The female sex pheromone of the spotted fireworm, a pest of gardenia, rose, mountain

laurel, and bayberry, was determined through capillary gas liquid chromatography and gas chromatography analysis. This finding contributes to the further understanding of the intraspecific pheromonal communication in this economically important group of insects.

Strain of Bacillus thuringiensis (B.t.) controls Colorado potato beetle and Mexican bean beetle - Beltsville, Maryland. In both laboratory and field tests B.t. killed 90 percent of first- and second-instar Colorado potato beetle larvae. Survivors developed into abnormal adults. Adults were not killed but ceased feeding. Weekly sprays protected potato, tomato, and bean field plots from damage. These findings may stimulate a reevaluation of microbial control technology with B.t..

Sprayer with metered, in-line mixing controls Colorado potato beetles - Wooster, Ohio. A commercially available, tractor-mounted sprayer was modified to mix precisely metered amounts of concentrated pesticide (carbaryl) with water in the spray-boom. Colorado potato beetles were controlled as well as when the same sprayer was used. This modified equipment reduces the handling of toxic pesticides, lessens the need for measuring, and alleviates problems that can occur when surplus spray materials remain in a tank.

Synthetic sex pheromone of the Japanese beetle attracts scarab beetle in Japan - Wooster, Ohio. When the synthetic female sex pheromone of the Japanese beetle was exposed in northern Japan, a scarab, *Mimela testaceipes*, was attracted in numbers along with males of the Japanese beetle. In addition to the interest created by this biological phenomenon, the response of *Mimela* to the pheromone indicated the availability of a potent survey tool, should this potentially damaging species ever be introduced into the United States.

Insect-resistant sweet potato breeding lines released - Charleston, South Carolina. Sweet potato breeding lines were released by the U. S. Vegetable Breeding Laboratory, South Carolina Agricultural Experiment Station, and Texas Agricultural Experiment Station. The lines have resistance to several species of insects that cause extensive damage to sweet potatoes in the U.S. This achievement may reduce or eliminate the use of insecticides for the control of the Southern potato wireworm, banded cucumber beetle, spotted cucumber beetle, sweet potato flea beetle, and white grubs, all of which are serious pests. Some of these lines, although not commercial varieties, may be used temporarily in areas where these insects cause severe losses to sweet potatoes and cannot be controlled by insecticides. The lines also add to the potential for development of acceptable varieties having insect resistance.

Use of light traps aid in pest management of nut casebearer - Brownwood, Texas. Light traps operated for several years at Shreveport, LA, and Brownwood, TX, have yielded information on moth activity, seasonal trends, and population densities of the nut casebearer. This information may assist growers in recognizing damaging populations and in determining optimum spray dates and effectiveness of treatments.

Integrated management of citrus insect pests improved - Weslaco, Texas. Ants were found to disrupt the regulatory capabilities of the citrus mealybug's natural enemy complex. Significantly higher mealybug population densities will prevail in the absence of ant control; therefore an effective integrated control program should consider ant control measures. Diazinon, the only registered

pesticide available to control ants in citrus, was effective for only 2 months which means that repeated applications may be required throughout the year.

The introduction and release of parasites that attack the citrus mealybug in Texas have resulted in the colonization of Leptomastidea abnormis and the establishment of Anagyrus pseudococcii. The latter has become at times the dominant parasite in the citrus mealybug's natural enemy complex in Texas. The parasite complex has increased from 3 species recorded in 1977 to 5 species in 1980, and it has significantly contributed to the development of a successful integrated control program for the citrus mealybug. The existing natural enemy complex of this mealybug was found capable of regulating the mealybug's population density below an economic injury level, if it is not disrupted by certain toxic pesticides. Thus, the use of pesticides has been reduced significantly, providing a savings in labor, energy, and cost of material and reducing the accumulation of environmental pollutants.

Antipheromones developed for insect control - Yakima, Washington.

Antipheromones (non-pheromone compounds that decrease captures of insects in traps baited with synthetic sex pheromones) may be used for control of codling moths either by themselves or as a new tool in integrated pest management. These compounds can effectively interfere with the ability of males to locate female moths. Because the antipheromone is less volatile than the pheromone and thus may be easier to formulate, and because it may not attract males into a control area as the pheromone does, it may be superior to the pheromone for mating disruption.

Seed-piece examination used as a method for sampling wireworm on potatoes - Yakima, Washington. Because preplant soil sampling is tedious and expensive, potato growers often treat their fields prophylactically without first sampling them. This can result in unnecessary applications of insecticides, particularly in fields with no history of wireworms or in fields that have previously been treated for wireworms. By examining seed-pieces (in potato hills) at postemergence in fields that have not been treated at planting time, a grower need apply insecticides only if damaging populations are present. This method should result in a reduction in cost and in environmental pollution.

Ash from Mt. St. Helens determined to be a very suitable substrate for crops - Yakima, Washington. Beans, carrots, corn, kale, peas, spinach, and turnips were seeded into pure ash, sand, and ash incorporated into soil by various methods. The vegetables grown in ash alone had the best germination, stands, and growth, at least until the nitrogen was depleted. Thus incorporation of the ash into the soil of crop lands is not detrimental, and is more likely to be beneficial, because the ash supplies nutrients other than nitrogen and aids in water retention. Using this information the City of Yakima planted a mixture of grasses on the areas filled with pure ash accumulated during the cleanup following the recent eruption.

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National Research Program 20230

COTTON AND TOBACCO INSECTS

This National Research Program involves development of new and improved practices for controlling insects attacking cotton and tobacco; these practices may be used alone or in integrated systems and on a farm-by-farm or area-wide basis. These control technologies include: genetic methods; attractants; parasites and predators; microbial agents; insect and plant growth regulators; insecticides; cultural practices; and resistant varieties. Survey methods, loss thresholds, and descriptive and predictive insect population models have also been studied to develop a basis for implementing various control technologies and for integrating them into total crop production systems. Application of research findings may result in insect control at reduced real costs and in improved environmental quality. Thus growers and consumers benefit.

Technological Objective 1: New and improved ecologically acceptable methods for reduction of losses caused by insects and mites attacking cotton.

NPS Contact: R. L. Ridgway

Research Locations:

Phoenix, Arizona  
Tucson, Arizona  
Mississippi State, Mississippi  
Stoneville, Mississippi  
Raleigh, North Carolina  
Florence, South Carolina  
Brownsville, Texas  
College Station, Texas

Examples of Recent Progress:

Sex-linked lethal strains of the pink bollworm isolated - Phoenix, Arizona.  
Four existing translocation strains have been taken through crossing procedures designed to produce homozygosity. They carry recessive lethal factors associated with the translocation, and thus they cannot be maintained as homozygous strains. These translocation strains are maintained as heterozygotes and crosses plus selection designed to eliminate such recessive lethal factors are planned for the coming year. Balanced sex-linked lethal stocks have not yet been recovered from irradiation tests of strains previously known to carry lethal traits.

High percentage of mated pink bollworm moths in diverse habitats - Phoenix, Arizona. Preliminary studies of the early season distribution and movement of pink bollworms were made during the 1980 season. In mark and recapture studies, males moved freely between desert, sugar beets, alfalfa, and cotton habitats during April and May. About 80 percent of female moths captured in light traps during this period were mated regardless of the habitat in which

they were captured. Virgin females placed in mini-mating stations in desert and cotton habitats were equally mated (ca. 50 percent) in a one-night exposure.

Populations of pink bollworm on St. Croix, U. S. Virgin Islands - Phoenix, Arizona. Sterile pink bollworms have been released on St. Croix and monitored during the year. Pink bollworm male moths were captured every month of the year in Sea Island cotton plots. The numbers ranged from ca. 0.2 to 1.5 males per trap/night. Highest numbers were caught during the period from November through April.

Pink bollworm mating disruption with gossyplure - Phoenix, Arizona. Gossyplure (1:1 mixture of Z,Z- and Z,E-isomers of 7,11-hexadecadien-1-ol acetate) in plastic laminated formulations of 35 or 10 g ai  $2.54 \text{ cm}^2$  have been applied at the rates of 2.96 to 4.94 g ai gossyplure per hectare to cotton fields. Applications have reduced male pink bollworm moth catches in pheromone-baited traps by an average of 80-85 percent (range 40-99 percent) and clipped-wing female mating in mating stations by 90-92 percent (range 52-100 percent) for 13-16 nights after application.

Computer program for timing application of pink bollworm pheromone - Phoenix, Arizona. Programs in BASIC have been written to predict the time pink bollworm pheromones should be applied to cotton planted on different dates. Programs have also been written to record pheromone trap catches, boll infestations, treatment dates, and costs for individual fields.

Multiple sources of germplasm with resistance to pink bollworm - Phoenix, Arizona. Several natural sources of resistance to pink bollworm have been isolated in cotton. No single source confers enough resistance to allow the crop to be grown without insecticide protection. However, sources can be combined; and thus, it becomes important to show that they exert their effects independently. Two sources, Texas 39 and AET-5, show low seed damage when they are exposed to natural field infestations of pink bollworm. Texas 39 also shows low seed damage when its bolls are infested artificially with pink bollworm eggs; larval mortality is high inside the bolls. AET-5, on the other hand, shows high seed damage when bolls are infested artificially, because its bolls offer little resistance to penetration of the larvae or to their development once inside. Therefore, it should be profitable to combine these two sources to increase the overall level of resistance.

Insect-resistant, short-season cottons and chemical termination combined to control pink bollworm - Phoenix, Arizona. Stoneville 825 nectariless and Deltapine 61 nectaried cottons have been grown by commercial farmers in a cooperative project between the University of California and USDA-SEA. Pink bollworm, lugus bug, bollworm, budworm, and cotton leafperforator populations were monitored in each cultivar throughout the 1980 growing season. Pink bollworm populations were low and did not differ significantly in numbers on the two cultivars. Lygus bug and cotton leafperforator populations were higher in the nectaried cotton than in the nectariless cottons.

Bacillus thuringiensis controls cotton leafperforator - Phoenix, Arizona. Applications of the bacterium, B. thuringiensis, to field cotton have resulted

in a ca. 90 percent reduction in cotton leafperforators on cotton. It gives acceptable control of this pest when applied on a weekly basis. Cotton treated with the nuclear polyhedrosis virus from the alfalfa looper has shown ca. 50 percent reduction in leafperforators. These results are similar to the effects previously observed in greenhouse tests.

High proportions of lygus bug eggs parasitized in alfalfa grown for seed - Tucson, Arizona. Up to 60 percent of the lygus bug eggs have been parasitized by the wasp Anaphes ovijentatus. However, the lygus bug passed through one generation and caused appreciable damage before the parasites reached these levels. The results suggest that augmentation of the native parasite population by releases of laboratory-reared wasps early in the flowering cycle may reduce lygus bug populations and damage.

Artificial diet and rearing system for lygus bugs - Tucson, Arizona. An artificial liquid diet for lygus bugs has been developed to allow more efficient rearing than that from previously used natural foods. The liquid can be contained in disposable packets on which the lygus bugs feed and lay their eggs. This rearing system may encourage more efficient and reliable production of predators and parasites for release in field control of lygus bugs.

Chemical sources of plant resistance to bollworms and budworms - Mississippi State, Mississippi. Gossypol, total phenols, tannins and catechins have been analyzed in 20 glanded and glandless cotton lines to determine the extent that their presence correlates with larval weight gains of bollworms and budworms in the field. ED<sub>50</sub> values have been obtained for isolated cotton constituents in the laboratory. A new anthocyanin with laboratory feeding resistance has been isolated from leaves.

Synthetic male and female pheromones combined to improve boll weevil trap efficiency - Mississippi State, Mississippi. In field studies in 1978, 1979, and 1980, the combination of male and female pheromones, which previously had been shown to be compatible, improved field catches by 15-20 percent. The female pheromone attracts fewer total insects, but 75 percent are males, indicating its specificity. Because the female components are relatively inexpensive, trapping efficiency can be improved economically. JH-III tripled the rate of pheromone biosynthesis of laboratory males giving a production even greater than that of males fed squares. This may make laboratory males more competitive than they are from current rearing procedures.

High-energy diets improve quality of sterile boll weevils - Mississippi State, Mississippi. Longevity of steriles can be increased with high-energy diets (about 1.2-1.9 days); longevity can also apparently be increased with reduced pressure while insects are being irradiated. Four high-energy slab diets have been tested to improve the quality of the sterile insect. LT<sub>50</sub> was increased by more than 1 day with high sugar and the Pharmamedia® diets.

New combinations of antibiotics for mass rearing of boll weevils - Mississippi State, Mississippi. Three antibiotic combinations were tested in the adult diet of the production colony. Fifty pairs were fed the combinations at 100 ppm; egg production, hatch, and mortality were recorded. The test was

replicated in time six times. Tetracycline plus ampicillin significantly reduced egg production and hatch percentage. Kanamycin plus chloroamphenical and streptomycin plus neomycin significantly increased hatch percentage.

Sperm from sterile boll weevils competed equally with sperm from normal boll weevils - Mississippi State, Mississippi. Eggs collected from females mated only to sterile males have shown 0 percent hatch at all ratios tested. The matings by normal males to normal females only have resulted in 80-90 percent hatch at the ratios tested. At ratios 1:1:1 to 1:20:1, the hatch of eggs collected from females mated to both sterile males and normal males has averaged 38.3 percent, which is slightly less than the median of sterile males and normal males combined. This indicates that the sperm from steriles compete about equally with sperm from the normal males in matings.

No evidence of resistance in the boll weevil to organophosphate insecticides - Mississippi State, Mississippi. Data on the 1979 responses of seven populations of boll weevils from six states and two populations from Mexico to azinphosmethyl, malathion, and methyl parathion have been submitted to probit analysis. The nine populations do not differ significantly.

Control of the bollworm and tobacco budworm by management of wild hosts - Stoneville, Mississippi. In the Delta the overwintered parental population and the F<sub>1</sub> larval generation of the bollworm and tobacco budworm depend on early-season wild host plants for survival and population buildup. The F<sub>1</sub> adult population of these two pests, which develop as larvae on early-season wild host plants, migrate to cotton and produce the initial bollworm and tobacco budworm infestation. Two properly timed mowings of these early-season host plants can destroy a high percentage of the F<sub>1</sub> eggs and larval and adult populations of these pests. This method of cultural control, if applied over a wide area, can be the foundation of an integrated pest control system.

Candidate insecticides effective against bollworm - Stoneville, Mississippi. Thirty-four insecticides, insecticide mixtures, and insect growth regulators have been evaluated for bollworm control in small-plot field trials. With the exception of three, all materials gave fair to good control of bollworm populations, with significant yield increases over those from untreated checks. The synthetic pyrethroids as a group continue to give excellent results.

Nectariless varieties reduce lygus bugs and increase yields - Stoneville, Mississippi. Use of nectariless cottons significantly reduces numbers of plant bug nymphs by 45 percent and adults by 26 percent. The yield studies imply that nectariless cottons reduce the yield losses due to plant bugs from 23 percent to 14 percent. Thus, the trait for resistance to plant bug, nectariless, reduces the need for chemical pesticide applications. In 1980, one commercial nectariless variety accounted for 7 percent of the U. S. acreage. In 1981, two commercial varieties are available, and nectariless is probably the most popular single variety.

Optimum pest management (OPM) trial for boll weevil - Stoneville, Mississippi. The OPM Trial is considered a biological success. Diapause boll weevil

control, the use of pheromone traps for surveys, regular scouting, and early and mid-season insecticide applications as needed, have prevented the need for mid-season insecticide applications for boll weevil control.

Release of backcross sterile tobacco budworms on St. Croix, Virgin Islands - Stoneville, Mississippi. Progress from 1978-1980 indicates that backcross insects reared at Stoneville, Mississippi, and released on St. Croix interact well with native insects with little selective mating. Since the release of sterile insects over the entire island, over 90 percent of the males trapped have been sterile, and suppression of the population is being accomplished. A more detailed understanding of the population dynamics of the tobacco budworm may be necessary before the level of suppression can be quantified.

Computer model used to estimate probability of achieving boll weevil eradication - Raleigh, North Carolina. A simulation model has been constructed to relate probability of trap capture to trap density and the total boll weevil population. The value used for probability of capture has been obtained from trapping experiments with known populations of weevils. This computer simulation model predicts that the boll weevil eradication trial has eradicated the boll weevil from the evaluation area by a probability exceeding 0.9983.

Eradication of the boll weevil in North Carolina greatly reduces insecticide use - Raleigh, North Carolina. The number of insecticide applications has been reduced in all areas sampled during the 3-yr period. The most dramatic reductions have occurred in the areas from which the weevil has been eradicated--Chowan County and the evaluation area. The average number of insecticide applications has declined as follows: for those fields samples in Chowan County, from 11.8 applications in 1978 to 0 applications in 1980 ; in the eradication evaluation area, from 10.8 in 1978 to 1.5 in 1980.

Beneficial insect populations increase after eradication of the boll weevil in North Carolina - Raleigh, North Carolina. Increases in numbers of beneficial insects have been largest in those areas experiencing the greatest decline in insecticide use. The average number of beneficial insects per hectare per week during July and August has increased about three-fold over a 3-yr period. In many cotton fields within the area where the boll weevil has been eradicated, beneficial insects have attained population levels that provide much of the control required to keep the bollworm at subeconomic levels.

Polyacrylamide gel electrophoresis used to examine the inheritance of esterases in the boll weevil - Florence, South Carolina. Individual zymograms exhibit 5 to 10 major bands that can be assigned to one of four zones, designated A through D from cathode to anode. Correlations of banding patterns between parents and progeny indicate the existence of at least two loci influencing migrations. The loci affecting zone A contain three codominant alleles each, those of zones B and C contain two codominant alleles each, and the locus of zone D contains four codominant alleles. This information and that on aldehyde oxidase, glutamate oxaloacetate transaminase, and phosphoglucomutase are valuable in identifying boll weevils from different sections of the country.

Diet of boll weevils influences vigor and response to pheromones - Florence, South Carolina. Boll weevils from artificial diet containing high protein and

low sugar are more active in a locomotor test and more susceptible to heat stress than similar weevils reared on diets with low protein and high sugar. This indicates that the effectiveness of sterile male weevils for release may be modified by their diet. Diets of squares, bolls, high protein:low sugar, and low protein:high sugar affect the responsiveness of the boll weevil to pheromone traps. Weevils fed squares and high protein:low sugar have been responsive to pheromone traps. In a boll weevil population model the diet of the weevil must be considered before trap captures can be used to predict field populations.

New record for distance in boll weevil migration - Florence, South Carolina. A wild boll weevil reared in the laboratory at Florence was marked and released near McBee, SC, when it was 6-8 days old. It was subsequently captured in a D-Vac sample near Candor, NC, on July 31, 1980. This weevil had moved 105 km in less than 48 days. This is a new record in boll weevil migration.

Pee Dee breeding lines with plant resistance to bollworms - Florence, South Carolina. PD 695 had shown less yield loss relative to the untreated check than have McNair 220 and Coker 310. Data continue to show that the numbers of larvae and squares damaged by bollworms and budworms on PD 695 are one-half those found on commercial cultivars. Yield differentials between treated and untreated plots were 36.6, 51.5, and 50.0% for PD 695, McNair 220, and Coker 310, respectively.

Effective new systemic and pyrethroid insecticides - Florence, South Carolina. The new systemic insecticide, Counter®, has been as effective as aldicarb when applied in a granular formulation for control of aphids, thrips, and spider mites. The synthetic pyrethroids, Pay-Off®, Cymbush®, Mavrik®, SD-92459, Ambush®, and Pydrin® are equally effective for control of bollworms.

Boll weevils may not diapause in subtropical climates - Brownsville, Texas. Tropical and subtropical weevils are unique physiologically and biochemically in that they overwinter in an active physiological state that cannot be defined as a classic diapause. Torpor or quiescence more accurately defines the physiological characteristics of these weevils during the fall and mild subtropical winters. The high metabolic activity of these weevils throughout the year is indicated from the laboratory measurements (conducted September-March 1979-80) of O<sub>2</sub> consumption and from flight in the field, indicated by trap catches during the winter at average minimum temperatures as low as 1.5° C.

Two different polyvinyl chloride (PVC) formulations of pheromones in tobacco budworm traps - Brownsville, Texas. The effectiveness of two PVC pheromone dispensers has been evaluated as bait for tobacco budworm survey traps. Maxi-capsule PVC dispensers function as well or better than laminated PVC (Hercon®) dispensers. Each dispenser type has been tested in replicated 2-wk baiting periods, and dosages have been either 10 mg or 20 mg per dispenser. The primary advantage of the use of the capsules is that individual researchers or survey entomologists can prepare these dispensers more economically than they can purchase the patented laminated PVC dispensers. Capsular PVC dispensers may cost 2-3¢ each, and the laminated product is 30¢.

Pheromone components reduce mating of budworms and bollworm - Brownsville, Texas. Virelure and the seven-component pheromone of the tobacco budworm have been field-tested in one-hectare cotton plots to determine their effect on mating reduction. Two rates (0.5 g and 1.0 g/hectare) have been dispensed from 500 cigarette filters on each of 3 test nights/concentration. Matings of clipped wing females have been reduced on mini-mating tables by 93.8 percent for 0.5 g virelure, 100 percent for 1.0 g virelure, 96.3 percent for 0.5 g seven-component, and 92.0 percent for 1.0 g seven-component. Trap captures have been reduced by 98.5 percent for 0.5 g virelure, 100 percent for 1 g virelure, 100 percent for 0.5 g seven-component, and 100 percent for 1 g seven-component. Also, moth flight activity has been reduced an average of 32.2 percent for all treatments.

Progress in development of slow-release dispenser of the bollworm sex pheromone - College Station, Texas. A thin laminated plastic dispenser containing all four components of the bollworm sex pheromone in ratios similar to those that occur naturally in the insects has effectively attracted males to cone traps. A 6.5-cm<sup>2</sup> dispenser containing 2.5 mg of pheromone has been effective for as long as 4 wks. Test results suggest that the concentration of pheromone in this dispenser can be reduced by half without loss of efficiency. The availability of an effective slow-release dispenser for the bollworm pheromone can greatly facilitate research on the practical use of pheromone-baited traps in IPM programs.

Pheromone traps for estimates of spring emergence of overwintered tobacco budworms - College Station, Texas. Studies of the spring emergence of overwintered tobacco budworms show that captures in the pheromone-baited traps accurately reflect the pattern of adult emergence that has been observed in screened cages erected over infested areas. Thus, data on captures of overwintered males in traps may be used in dynamic population models that are used to forecast population trends. Also, the synchrony between overwintered adult emergence and captures in the pheromone traps suggests that the initial tobacco budworm colonization originated locally rather than from immigration.

Pheromone components trap catch of bollworms - College Station, Texas. None of the 12 degradation products of each virelure component [(Z)-11-HDA1 and (Z)-9-TDAL] has affected catches of male tobacco budworms in traps baited with the synthetic pheromone. Also, none of the degradation products of (Z)-11-HDA1 has affected catch of male bollworms in traps baited with the four-component synthetic bollworm pheromone. However, two of the three components that are found in the tobacco budworm but not in the bollworm have caused a reduction in the numbers of male bollworms attracted to traps: the compound (Z)-9-TDAL has caused a 96 percent reduction, and (Z)-11-hexadecen-1-ol has caused a 96 percent reduction. The other component, tetradecanal, has not affected the response of male bollworms to traps. Thus, both (Z)-9-TDAL and (Z)-11-hexadecen-1-ol are important in regulating the specificity of the pheromonal signals of the two species.

Chlordimeform as a selective insecticide that is not harmful to the egg parasite, Trichogramma - College Station, Texas. Laboratory tests of the effects of insecticides on the egg parasite, Trichogramma, have shown that spray applications of methomyl, methyl parathion, and permethrin at the rates

recommended for field use cause a drastic (ca. 90 percent) reduction in the parasitism of host eggs when sprays are applied before eggs are exposed to the parasites. Similar applications of the ovicide chlordimeform have had little adverse effect. When eggs are exposed to parasites and then sprayed with the insecticides, adverse effects on immature stages developing within treated eggs are minimum. These results suggest that field releases of parasites and applications of chlordimeform may be compatible. Very careful timing of applications may allow the joint use of parasites and insecticides in pest management programs.

Tolerance of field populations of the tobacco budworm to methyl parathion and permethrin - College Station, Texas. A wild strain of tobacco budworm has been collected in Central Texas from an area of heavy insecticide use, and studies show that third-stage larvae of its first field generation are ca. 16 times more tolerant to methyl parathion and ca. 20 times more tolerant to permethrin than larvae from a susceptible strain. Similar comparisons during August in the same area with pheromone traps indicated that adult tobacco budworm males are ca. four times more tolerant of methyl parathion and ca. six times more tolerant of permethrin than susceptible males. Studies to determine possible mechanisms contributing to the increased insecticide tolerance in adults indicate that acetylcholinesterase in heads of wild males is significantly less sensitive to organophosphorus (OP) insecticide inhibition than it is in heads of susceptible insects. This factor and the reduced penetration and increased detoxification of pesticides reported to occur in resistant tobacco budworm larvae contribute to OP resistance in field populations.

Crop oil increases effectiveness of diflubenzuron control of boll weevil - College Station, Texas. Replicated tests in cotton fields 4 ha or larger provide definite evidence that applications of mixtures of diflubenzuron and water are somewhat less effective against natural populations of the boll weevil than are mixtures of diflubenzuron with water and a crop oil. These tests confirm previous reports that diflubenzuron has little impact on populations of beneficial species or bollworms and budworms and show that cotton in fields treated with diflubenzuron set a better bottom crop of bolls than do fields untreated or treated with conventional insecticides.

Technological Objective 2: New and improved methods to improve safety of tobacco through improved insect control.

NPS Contact: R. L. Ridgway

Research Locations:

Oxford, North Carolina

Examples of Recent Progress:

Bacillus thuringiensis effective for control of tobacco budworm - Oxford, North Carolina. Four isolates of B. thuringiensis var. kurstaki (HD-1, HD-241, HD-244, HD-263) have been tested against budworms at 1/8, 1/4, and 1/2 lb/A with and without the adjuvant, Coax®. All treatments are equally effective.

Glandless tobacco resistant to tobacco budworm - Oxford, North Carolina.

Tobacco lines lacking glands on trichomes have shown resistance to H. virescens through ovipositional nonpreference. Chemicals lacking include duvatriene diols and C<sub>20</sub>-28 fatty alcohols. Applications of these chemicals to resistant plants induce oviposition by budworms. Because early-season budworm populations are usually too low for a valid test of insect resistance, the plantings are cut back to provide new growth when insect populations are high. Chemical levels in the tobacco regrowth have been higher than those in early- or late-planted tobacco, and these plants attract the most insects.

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INSECT CONTROL - GRAINS, FORAGES, SUGAR CROPS, AND OILSEEDS

Technological Objective: Reduce losses in field crops by conducting research to develop new and improved control of insects and mites.

This National Research Program involves research in developing new and improved control methods, tactics, and strategies that may be used singly or combined in integrated systems to reduce pest insect populations and losses to corn, small grains, sorghum, millets, grass and legumes, forages, sugar-beets, sugarcane, soybeans, peanuts, and other field crops.

NPS Contact: Robert D. Jackson

Research Locations:

Tucson, Arizona	Stoneville, Mississippi
Canal Point, Florida	Columbia, Missouri
Tifton, Georgia	Bozeman, Montana
Kimberly, Idaho	Lincoln, Nebraska
West Lafayette, Indiana	Fargo, North Dakota
Ankeny, Iowa	Wooster, Ohio
Manhattan, Kansas	Stillwater, Oklahoma
Crowley, Louisiana	Corvallis, Oregon
Houma, Louisiana	University Park, Pennsylvania
Beltsville, Maryland	Brookings, South Dakota
East Lansing, Michigan	Bushland, Texas
Mississippi State, Mississippi	Logan, Utah
	Yakima, Washington

Examples of Recent Progress:

Corn:

Plant attracts corn earworm for oviposition - Tifton, Georgia. A laboratory test has been used to effectively assay plant extracts and identify plant chemicals that attract the corn earworm for oviposition. The demonstrated effectiveness of this method may open the way for characterization of plant species or varieties that are less attractive to *Heliothis zea* for oviposition.

Plant odors affect behavior of parasitic insects - Tifton, Georgia. Laboratory bioassays provide evidence that female *Trichogramma* wasps use the same chemicals that stimulate corn earworms to oviposit to locate plants on which to search for corn earworm eggs. This indicates the role of plant odors in parasite search behavior and may provide a basis for understanding and manipulating the behavior of both beneficial and pest insects.

Improved efficiency of *Trichogramma* species - Tifton, Georgia. The use of *H. zea* eggs as hosts has significantly increased the subsequent rates of parasitization by the reared *Trichogramma prediosum*. The use of natural or factitious hosts should substantially increase the probability of success in the use of *Trichogramma* spp. to manage *Heliothis* spp. in row crops.

Control of aflatoxin production on crops in storage seems possible - Tifton, Georgia. Volatile compounds found in corn silk offer the possible means to stop the production of aflatoxin in agricultural products in storage. The possibility of obtaining a use patent for these compounds is being explored by the University of Georgia and USDA. The compounds are commercially available and are active at low levels and are thus expected to provide economical control.

Sex pheromone released into the environment reduces mating by corn earworm - Tifton, Georgia. In studies with large screened cages covering host plants, mating by *H. zea* has been reduced when adults are released into the pheromone-treated cages. The full-component pheromone was dispersed from cigarette filters at a rate equivalent to 370 g/ha from the equivalent of 3700 sites/ha. About 13% of the pheromone evaporated in the 7-h tests, and mating was significantly reduced compared to that in an untreated check.

New resistant corn inbreds registered - Tifton, Georgia. Two sweetcorn inbreds, GTS-1 and GTS-2, with resistance to corn earworm were registered by the Crops Science Society of America.

Corn with both non-preference and antibiosis types of resistance to the fall armyworm identified - Tifton, Georgia. Three years of results show that Antigua 2D-118 produces about one-half as many fall armyworm adults as does the susceptible standard. Detailed studies indicate that both non-preference and antibiosis resistance are present in Antigua 2D-118 and MPSWCB-4. Improvements in providing infestations of fall armyworm larvae to experimental germplasm have accelerated the selection for fall armyworm resistance.

Initiation of epizootics of nuclear polyhedrosis viruses (NPV) in corn earworm and fall armyworm - Tifton, Georgia. In second-crop corn with heavy populations of corn earworm and fall armyworm, only two applications of NPV have been necessary to start epizootics that remain with the crop throughout the season. Thus, a significant reduction in populations of fall armyworm in corn may be achieved with as few as two applications of NPV.

A new species of *Vairimorpha* from Bolivia with potential for suppression of fall armyworm and corn earworm - Tifton, Georgia. A protozoan pathogen isolated from cotton leafworm from Bolivia has been compared to other species of *Vairimorpha*. It has more potential for suppression of populations of fall armyworm and corn earworm than the others, because it combines high infectivity with the ability to be transmitted from infected females to their progeny. If this pathogen proves to be compatible with parasites and predators, it could be introduced into the populations of corn earworm and fall armyworm and allowed to spread naturally. This may suppress the populations of both pest species.

Fall armyworm resistant to several insecticides - Tifton, Georgia. Fall armyworms continue to be resistant to carbaryl, trichlorfon, and methyl and ethyl parathion, as has been reported. Collections of fall armyworm from Georgia, Louisiana, and South Carolina have also been found to be resistant to methomyl. If resistance to methomyl becomes widespread, no areawide approved insecticide will be available for control.

Insect control through use of irrigation systems - Tifton, Georgia. Effective control of corn earworm, fall armyworm, and lesser cornstalk borer can be achieved when insecticides are metered into and applied through sprinkler irrigation systems. Large volumes of irrigation water can be used for application, and the cost is less than applications with aerial and ground equipment. Non-emulsified formulations give control superior to that obtained with standard or emulsifiable concentrate formulations. Applications are made with a closed system, do not require the use of labor, and can be made during conditions unfavorable for conventional application.

Complete system for double-cropping of corn - Tifton, Georgia. Corn hybrids for grain and silage should show fall armyworm resistance and other performance characteristics to be suitable for summer planting in a corn-to-corn double-cropping system. Such hybrids can be grown in a cultural system that combines minimum use of insecticides with its accompanying low cost, and the use of irrigation system. This system allows the production of two corn crops annually.

Radar study of insect flight - Tifton, Georgia. A program using radar to study insect flight in southeastern United States began in August 1980. Radar provides new information about high-altitude movement of insects. Insect flight, a very important part of insect life cycles, has been difficult or impossible to study by other methods. This information is needed for planning pest control strategies.

Interaction between European corn borer infestations and stalk rot - Ankeny, Iowa. Genotypes of corn resistant to stalk rot do not maintain resistance when they are subjected to heavy infestations of the European corn borer. However, genotypes resistant to the European corn borer show little damage by stalk rot.

Sampling method for predicting the timing and quantity of egg masses from second-generation European corn borer - Ankeny, Iowa. The results of a 5-yr study show that sampling adult European corn borer moths in dense grass surrounding corn fields can provide data that allow prediction of the time and quantity of egg masses of second-generation European corn borer.

Both pheromones and blacklight traps necessary for monitoring black cutworm flight - Ankeny, Iowa. Results of studies monitoring the activity of black cutworm adults indicate that pheromone traps are effective in determining the start of black cutworm flight and that blacklight traps are effective in determining flight peak. Thus, both trap types are needed to make the most accurate measures of flight activity.

Myzus persicae and Rhopalosiphum maidis found to be the most important vectors of maize dwarf mosaic virus (MDMV) in Ohio - Wooster, Ohio. Aphids most frequently associated with MDMV transmission in Ohio are M. persicae, Rhopalosiphum maidis, Aphis gossypii, Dactynotus ambrosiae, and Hyalopterus atriplicis. M. persicae and R. maidis are the most important vectors in southern and northern Ohio, respectively.

Eggs of northern corn rootworm and western corn rootworm differ in ability to survive winter temperatures - Brookings, South Dakota. Studies of the cold-hardiness of eggs of the northern corn rootworm, Diabrotica longicornis barberi, indicate that about 50% of the eggs survive  $-10^{\circ}$  C. after 7-wk exposure, while none of the eggs of the western corn rootworm, Diabrotica virgifera, survive after 2 to 4 wk exposure at  $-10^{\circ}$  C. Hatch of the two species has been about the same when exposed to temperatures of  $-5^{\circ}$  C.,  $0^{\circ}$  C., and  $+10^{\circ}$  C. Mortality is apparently greater at 30% moisture after 1 wk exposure than at 5, 10, and 20% moisture.

The sex pheromone of the western corn rootworm identified and synthesized - Brookings, South Dakota. The major, if not the only, component of the sex pheromones of the western corn rootworm has been identified as 8-methyl decane-2-OL propionate (8-MDP). This compound has been synthesized at Gainesville, Florida, and has been found to be identical to the pure western corn rootworm pheromone, as identified through cooperative research between Brookings and Gainesville. The synthetic 8-MDP attracts the western corn rootworm, the northern corn rootworm, and the Mexican corn rootworm. The response of the western corn rootworm in the field increases with increasing pheromone concentration, but the response of the northern corn rootworm diminishes when concentrations per trap reach 10 micrograms or more of 8-MDP.

Taxonomic relationships of Diabrotica virgifera, D. longicornis, and other Diabrotica - Brookings, South Dakota. Distribution maps have been completed and descriptions have been partially completed for 13 species of Diabrotica. All 13 species have been illustrated. The species were studied in order to resolve their status in the D. longicornis complex. Some 367 beetles of the D. l. longicornis - D. l. Barberi complex from and near the area of sympatry have been subjected to discriminate analysis of 20 morphometric characters; 74% of the females and 77% of the males have been correctly classified. Male genitalia show no differences. Clear differences in choice of habitat and pheromone response have been established. Isozyme analysis (14 systems) reveal no diagnostic loci but gene frequencies differ between field populations.

#### Small Grains and Rice:

Two new wheat genes for resistance to Hessian fly - West Lafayette, Indiana. Genes  $H_{10}$  from the common wheat Elva and  $H_{11}$  from durum wheat PI94587 have been added to the supply of genetic stocks with resistance to Hessian fly biotypes. These genes confer resistance in wheat to all known biotypes of Hessian fly.

Genomes in wheat confer resistance to biotypes of Hessian fly - West Lafayette, Indiana. Genes  $H_3$ ,  $H_6$ ,  $H_9$ , and  $H_{10}$  have been located on chromosome 5A in the A genome. Genes  $H_{11}$  and  $H_5$  are linked in the B genome, and the new resistance

from *Triticum tauschii* is derived from the D genome. These data show that resistance to Hessian fly can be derived from all three genomes of common wheat.

Wheat varieties with resistance to Hessian fly protect the wheat crops in four States - West Lafayette, Indiana. Wheat surveys in Illinois, Indiana, Michigan, and Ohio show very low infestations of Hessian fly. The mean percent infestations for 1,302 fields of wheat in the Midwest was only 2.1% for the crop year 1979-1980. These data demonstrate that resistant varieties continue to protect the wheat crop from serious losses from Hessian fly.

Two new wheat cultivars with resistance to Hessian fly in the eastern United States and resistance to barley yellow dwarf virus - West Lafayette, Indiana. Wheat varieties Caldwell and Auburn have been released to seed growers in Indiana and adjoining States. These wheats are resistant to the prevalent biotype B of Hessian fly and to Indiana strains of the barley yellow dwarf virus.

Wheat breeding lines from Great Plains breeding programs evaluated - Manhattan, Kansas. About 3,500 early- and advanced-generation wheat breeding lines from Great Plains breeding programs have been evaluated for resistance to Hessian fly biotypes. Plants with Marquillo,  $H_3$ ,  $H_5$ , or  $H_6$  genes combine resistance to the Hessian fly and wheat diseases. This research is carried out in cooperation with wheat breeders in Kansas, Nebraska, Missouri, Oklahoma, and South Dakota.

*Triticum tauschii* with stable resistance to Hessian fly - Manhattan, Kansas. Data from  $F_4$  lines derived from crosses between synthetic hexaploid wheats with resistance to Hessian fly and susceptible common wheats bred true for resistance. These data confirm that the *T. tauschii* chromosome with resistance is stable and can be readily transferred to common wheat. Preliminary results also indicate that resistance from *T. tauschii* is not affected by high temperatures (28° C.).

Resistance to rice water weevil in rice lines - Crowley, Louisiana. A replicated test of 34 rice lines selected from 2,735 World Collection lines screened in 1979 has shown that eight of these lines have moderate levels of rice water-weevil resistance. Infestation levels on these lines have been at least 40% lower than infestation levels on check varieties.

New greenbug biotype in the Great Plains - Stillwater, Oklahoma. During 1980, a new greenbug mutant, designated as biotype E, overcame much of the commercial and experimental plant resistance found in small grains and sorghum. Amigo-type resistance in wheat has been lost; the *Triticum tauschii* selections, though not as advanced, are still resistant. Rye is now segregating for resistance. Barley has lost its tolerance to the new biotype but has maintained the antibiosis. Oats is the only small grain that has not been affected by the appearance of biotype E. Biotype E now extends from the High Plains of Texas northward to Minnesota.

Wireworm trap developed - Yakima, Washington. Several conditions of bait type and treatment, cover material, and time of exposure to wireworms have been field tested. Most wireworms have been trapped with a 1:1 mixture of corn and wheat, presoaked with water, covered with polyethylene sheets, and left in the field for 3 wk. More wireworms were collected in April than in any other month.

### Sorghum and Millet:

Techniques improved for screening and evaluating sorghum for insect resistance - Tifton, Georgia. A pressure applicator has been used to infest sorghum heads with corn earworm eggs. Researchers have detected differences in resistance among sorghum genotypes through the damage produced by the larvae from this infestation. In a 2-yr field study to evaluate procedures and methods for infesting corn earworm eggs on heading sorghum, we have found that rate of establishment is high when plants are infested at the early flowering stage as compared to the boot stage. No differences in corn earworm establishment were detected among genotypes. Sixty corn earworm eggs per head results in more corn earworm establishment than do 30 corn earworm eggs per head. The placement of a pollinating bag over the head after an infestation also increases rates of establishment.

Resistant germplasm identified - Lincoln, Nebraska. Resistant germplasm has been identified among 50 grain sorghum lines naturally infested with second-generation chinch bugs. The lines differed in plant survival, leaf necrosis, stunting, and ability to form heads. A number of breeding lines in the F<sub>6</sub> to F<sub>8</sub> generations also carry resistance to the biotype C greenbug.

Economic injury level of greenbugs on sorghum determined - Lincoln, Nebraska. In a field test with greenbugs on resistant grain sorghum, the economic loss of 140 kg/ha was associated with about 220 greenbugs per plant and 1,600 aphid days. Sorghum producers can use this information to determine time of application of control measures.

### Grasses and Legumes:

Differences in Arizona and Idaho populations of pea aphids - Tucson, Arizona. A new virulent biotype of pea aphid from Idaho has been found while evaluating peas and lentils for resistance to two pea aphid populations. Lentils and peas are more severely damaged by the Idaho aphid population than by the Arizona population; however, the Arizona population is much more virulent on alfalfa than is the Idaho population.

Australian alfalfa germplasm provides source of resistance - Tucson, Arizona. A new experimental alfalfa with high resistance to the spotted alfalfa aphid was developed from the Hunter River variety from Australia. Resistance percentage has increased from 0.5 to 26.5 in the first cycle of selection and from 26.5 to 76.8 in the second cycle of selection after 2 yr of tests.

Cultural practices reduce damage to Bermudagrass by fall armyworm - Tifton, Georgia. Research has shown that fall armyworm damage can be avoided by proper harvest and frequent fertilization of Bermudagrass. Damaging populations of fall armyworms do not normally appear in coastal Bermudagrass in south Georgia until late July to August. A split application of nitrogen applied by June 1 produced 83-86% of the total annual yield before the buildup of severe fall armyworm populations. Over 4 million hectares of coastal Bermudagrass are currently being grown in the South, and this procedure could save at least 10% of the seasonal yield.

Technique developed to select Kentucky bluegrass with resistance to the greenbug - Beltsville, Maryland. A laboratory screening program has been developed to select for greenbug resistance in Kentucky bluegrass. The program uses a seedling test as an initial screening step, followed by individual evaluation of plants selected for seedling resistance. Plants expressing resistance in the second test are retained for additional testing and clonal increase. This is the first laboratory screening program developed to select for greenbug resistance in Kentucky bluegrass; it has considerable value for turfgrass breeding programs.

Technique for enhancing chinch bug infestations - Beltsville, Maryland. Chinch bug populations have been significantly increased in red fescue plots that were artificially infested with laboratory-reared adults in July. The plots enclosed within screen barriers or within screen cages were first infested with 200 adults each. In September, about 15,000 insects, a 12.5X increase, were collected from the six cages in the study. This procedure provides a method for raising chinch bugs and concentrating populations for quick retrieval. Insects collected in this manner can be used to infest field trials or to provide a source for laboratory colonies.

Nosema locustae effective in reducing grasshopper populations in the second year after treatment - Bozeman, Montana. In 1979, 2,330 hectares of rangeland were treated with *N. locustae* for grasshopper control but were inadvertently treated with doses lower than those intended. Because of the low dose, infections in 1979 were low and never exceeded 13% in the population. In early May of 1980, about 20% of *Psoelessa delicatula*, which overwinters as late-instar nymphs, were found to be infected with *N. locustae*. This information showed that the inoculum increased during the season and successfully survived the winter. From late May to July grasshopper population densities in the control plots nearly doubled due to the continuing egg hatch and exceeded the economic threshold of eight grasshoppers per square meter in two of the three areas. During the same period population densities in the *Nosema*-treated plots were reduced by 50%, to less than two grasshoppers per square meter. *N. locustae* apparently took longer to produce intended results because of low treatment rates, but the pathogen did reduce populations significantly in the second year.

Negative impact of robber flies on biological control of grasshoppers - Bozeman, Montana. Robber flies have been observed to prey upon grasshopper parasites in the field. A caged study was started to determine the impact of this predation upon biological control of grasshoppers. When robber flies were confined to cages with grasshoppers and their sarcophagid parasites, the robber flies killed the parasites, prevented parasitism, and enhanced grasshopper survival.

Alfalfa with multiple pest resistance - Lincoln, Nebraska. A new alfalfa variety, 'Perry', previously designated NS-82, has been developed jointly by USDA and the Nebraska Agricultural Experiment Station. It was released jointly with the Nebraska, Kansas, South Dakota, and Wisconsin experiment stations in October 1980. This new variety has at least some degree of resistance to four insect pests (alfalfa weevil, potato leafhopper, pea aphid, and spotted alfalfa aphid) and three diseases of alfalfa (bacterial wilt, downy mildew, and anthracnose). It is anticipated that this variety, with multiple pest resistance, will be an important contribution to the management of these insects and diseases.

Success in disrupting the sex-pheromone communication of the cranberry girdler moth - Corvallis, Oregon. Hand-deployed pheromone evaporator stations 10 m apart on one-half hectare plots reduce trap catches by 100%. When evaporator stations are 30 m apart, trap catches are reduced by 76%. Further testing may show if commercial formulations can prevent mating by the cranberry girdler, a serious pest of grasses grown for seed.

Glandular hairs for resistance to alfalfa insects - University Park, Pennsylvania. Sticky hairs located on lower leaf surfaces of some annual legumes, closely related to alfalfa, have been found to confer resistance to attacks by the alfalfa blotch leaf-mining fly. The sticky hairs reduce the number of eggs laid by female flies, and consequently fewer leaf miners develop inside of the leaves. Most alfalfa plants have simple hairs on the leaf surfaces, and they do not affect egg-laying by the leaf miner females. Alfalfa lines with sticky hairs would resist several insects, including the alfalfa blotch leaf miner.

Identification of plants with resistance to the clover root curculio - University Park, Pennsylvania. A slant-board culture method was used to evaluate legumes for resistance to the feeding by the clover root curculio, *Sitona hispidulus*. Twelve alfalfas from diverse geographic origins are rated susceptible to *S. hispidulus* larvae. Also susceptible are Arlington, Penscott, and Kenstar red clover cultivars and Regal and Ladino white clover. However, Penngift crownvetch, Bigflower vetch, and Dawn, Empire, and Viking birdsfoot trefoil are resistant to *S. hispidulus* and to a second curculio, *S. flavescentis*. Removing nodules from roots of susceptible plants adversely affects developmental time of *S. hispidulus*.

#### Sugar Crops:

Losses in sugarcane yield vary among varieties - Canal Point, Florida. In studies to determine the effect of sugarcane borers on sugar yield in infested sugarcane, linear regression analysis has shown that Brix, sucrose, purity, sugar per ton of cane, average stalk weight, and juice extraction are reduced as a number of bored internodes increases. An average of one bored internode per stalk reduces sugar per ton of cane by 2.82 kg/mt. Sugar loss varied among varieties, with CP 56-59 and CP 65-357 having only about one-half the loss of variety CP 63-588 and CL 59-1052.

Sticky stake traps used in pest management of the sugarbeet root maggot - Kimberly, Idaho. Sticky stake traps have been developed to survey adults of the sugarbeet root maggot, *Tetanops myopaeformis*. Catches by these traps correlate well with the subsequent damage by sugarbeet root maggot larvae. These trap catches can be used to time insecticide applications, thus reducing the need for routine preventive applications.

Progress in development of sugarbeet germplasm with resistance to the sugarbeet root maggot - Kimberly, Idaho. Progeny of the fifth cycle of selection for resistance of the sugarbeet root maggot have sustained only 70% the damage sustained by the original parent. Development of resistant germplasm is continuing.

Pyrethroids control western bean cutworm - Kimberly, Idaho. Laboratory and field tests with insecticides indicate that several materials are superior to the currently registered compounds for control of bean cutworm. Fenvalerate and permethrin are particularly effective. Research also shows that control can be substantially increased with the proper timing of applications in relation to moth flight.

Ants important in control of sugarcane borers - Houma, Louisiana. Predation of sugarcane borer larvae by ants has averaged 28.1, 38.4, and 44.5% in plant, first, and second stubble sugarcane crops evaluated areawide in large-plot field trials. The presence of weeds that harbor insects used as prey by ants is described as the factor most responsible for increased predation by ants in Louisiana sugarcane fields.

Oilseed Crops:

Leaf consumption by the fall armyworm related to peanut development - Tifton, Georgia. Fall-armyworm leaf consumption and survival has been found to be related to leaf and plant age on Florunner peanuts, the most widely grown peanut in the Southeast. Over 80% of the damage by the fall armyworm is caused by the last two larval instars. These findings are directly applicable to insect-pest management in peanuts and significantly aid in treatment recommendations for this insect.

Pheromone of lesser cornstalk borer synthesized and field tested - Tifton, Georgia. The pheromone of the lesser cornstalk borer has been isolated, synthesized, and found to be highly attractive to male moths under field conditions. The lesser cornstalk borer is one of the most destructive pests of peanuts throughout the peanut-growing area. It is one of the hardest insects to monitor, because it is primarily a subterranean pest. The pheromone monitoring system will help in timing treatments to control economic damage.

Egg parasites from six countries screened for potential release against the southern green stinkbug - Stoneville, Mississippi. Seven species of stinkbug egg parasites have been screened at the Stoneville research quarantine facility. Host ranges and life histories have been studied, and two species (*Telenomus chloropus* from Japan and *Ooencyrtus* sp. from Thailand) have been retained for further study. Permits to release *T. chloropus* have been secured, but no releases have been made due to lack of diverse genetic stock. Females of a native parasite, *Trissolcus basalis*, successfully compete with *T. chloropus* for control of egg masses of stinkbugs, and only *T. basalis* emerges when eggs are also parasitized by both parasite species. *T. chloropus* also accepts eggs of both the brown and the rice stinkbugs.

Natural control reduces tobacco budworm larvae on soybeans - Stoneville, Mississippi. Natural control of tobacco budworm larvae is one of the elements that affects the relationship of rates of infestation and subsequent pod and seed damage. The natural control factors cause high mortality in third-stage larvae before they cause significant damage. Infestations of 23 third-stage larvae per meter of row can be reduced to 3.3 per meter in 5 days.

Soybeans most susceptible to damage by an infestation of third- and fourth-stage *Heliothis* larvae coinciding with first appearance of pods - Stoneville, Mississippi. Third- to fourth-stage *Heliothis* sp. larvae destroy an average of 76 seeds per larvae when infestations occur at first-pod development. Damage has not differed for four cultivars tested. This finding will aid producers in determining when chemical controls are justified.

Compound in sunflower seeds found to confer resistance to the sunflower moth - Bushland, Texas. Research has shown that phytolelanin in the seed wall of sunflowers is a significant factor in protecting sunflower seed from injury by larvae of the sunflower moth. An accurate estimate of seed injury cannot be determined by anthocyanin pigmentation or by sclerenchyma thickness in the seed wall. Thus, these factors are not considered important in host-plant resistance. It has been shown that the presence of phytolelanin is independent of total seed wall thickness and has no influence on it. Thus its character can be used as a resistance mechanism against the sunflower moth without influencing the seed yield or oil content. The expression of phytolelanin is controlled by a single dominant gene and is inherited independently of other seed wall characteristic studied.

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National Research Program 20250

BASIC/NON-COMMODITY RESEARCH FOR INSECT CONTROL

This National Research Program includes basic research on entomological problems regardless of the affected commodity or U.S. Department of Agriculture mission. Chemists, physiologists, ecologists, and behaviorists work in teams to provide the in-depth fundamental knowledge needed in applied research programs on insect management.

NPS Contact: Waldemar Klassen

Technological Objective 1: Develop new and improved principles and practices of arthropod control based on the selective disruption of growth, development, and reproduction.

Research Locations:

Gainesville, Florida  
Beltsville, Maryland  
Fargo, North Dakota

Some examples of recent progress are:

Development of a cell line from imaginal wing discs of the cabbage looper - Gainesville, Florida. Tissue cultures of intact imaginal discs have been used in numerous studies of hormonal control of insect development. However, such experiments have been limited by the difficulty of surgically preparing sufficient biological material for biochemical experiments. Therefore, our objective has been to obtain cell lines from these tissues to provide a plentiful source of homogeneous cells for in vitro examination. We have developed a unique cell line that has been subcultured at weekly intervals since January 1980. Our biochemical studies with 20-hydroxy-ecdysone show that the IAL-TND1 cell line can be a significant tool in studies of hormonal mode of action and development.

The endocytotic mechanism of protein transport through cell membranes of insect fat body - Gainesville, Florida. There is considerable interest in the basic problem of protein transport through cell membranes. We have developed a model system that explains the accumulation of storage protein in wax moth larvae. Our research shows that primary functions of fat bodies in last larval instar are the synthesis and export of large quantities of storage protein. We have also shown that both processes are prevented by the glycosylation inhibitor, tunicamycin. Our findings, along with other information, demonstrate that the export and uptake of storage proteins by fat body depend upon for recognition the glycosyl residue on the protein at the membrane transport site. Phenomena described by these results affect both the mechanism of protein transport across cell membranes and the transport of biologically active chemicals such as hormones.

Bioassay of effects of chitin synthesis inhibitors on reproduction system - Beltsville, Maryland. Chitin synthesis inhibitor can be detected by adding as little as 100  $\mu$ l of inhibitor solution to a single pharate adult clasper of the European corn borer. Because chitin synthesis inhibitors are potentially important insecticides that can interfere with reproduction, a bioassay involving reproductive tissue has been needed. This bioassay can be carried out rapidly with small amounts of test compounds.

Changes in osmotic pressure as a factor in control of spermatogenesis - Beltsville, Maryland. Two factors affecting spermatogenesis in the tobacco budworm, *Heliothis virescens*, have been investigated: hemolymph osmotic pressure and hormones. As hemolymph osmotic pressure rises during diapause, spermatocyst development is inhibited and mature sperm disintegrate. However, premeiotic immature spermatocysts are maintained at high osmotic pressure. At termination of diapause, *in vivo* hemolymph osmotic pressure falls and spermatocysts develop.

Separation of pairs of C-24 epimeric sterols by capillary GLC - Beltsville, Maryland. Hitherto, pairs of C-24 epimeric sterols have not been separated by any physical method. The trimethylsilyl ethers of nine pairs of such sterols have been partially or completely separated by glass capillary gas-liquid chromatography. The method now permits rapid quantitative analyses of C-24 epimeric sterols from both plants and animals. Most importantly, the method permits studies with C-24 alkyl-substituted sterols in areas of research previously considered unapproachable. (Cooperative research with Mr. R. H. Thompson and Dr. H. T. Slover, Nutrient Composition Laboratory, Human Nutrition, and Dr. G. Patterson, Department of Botany, University of Maryland).

The relationship of structure and activity of brassinosteroids - Beltsville, Maryland. Studies of the relationship of structure and activity in synthetic brassinosteroids have permitted us to determine the minimum structural requirements for a brassinolide-like substance that promotes plant growth and to determine which brassinosteroid is the most active, the cheapest, and most practical to produce. This study may allow more testing of increased vegetative growth and crop yield in a wide diversity of plants under greenhouse and field conditions. (Cooperative Research with Drs. N. Mandava and W. J. Meudt, Plant Hormone and Regulators Laboratory, PPhI).

High hormonal activity of makisterone A in adult milkweed bugs - Beltsville, Maryland. The ecdysteroid, makisterone A, has been identified in our laboratory as the predominant molting hormone in 4-day-old eggs of the milkweed bug. It has also been injected into adult females to investigate its hormonal activity, if any, in a non-embryonic stadium of the insect. Makisterone A is about 10X more active than 20-hydroxyecdysone in suppressing yolk deposition (vitellogenesis) and in stimulating the secretion of a new cuticle in adult female milkweed bugs. Suppression of vitellogenesis by ecdysteroids has been attributed to an indirect humoral inhibition of juvenile hormone synthesis, thus implicating an as yet unidentified third hormone in the reproductive cycle of this insect.

Endogenous 24-methylenecholesterol in honey bee workers transferred to brood - Beltsville, Maryland. We have verified the transfer of  $^{3}\text{H}$ -24-methylene-cholesterol through two generations of honey bee progeny by feeding it in a semidefined diet to workers and examining the sterols of prepupae from brood

reared by workers of the next generation (fed unlabeled cholesterol). Ca. 20% of the sterols of these second generation prepupae was comprised of  $^3\text{H}$ -24-methylenecholesterol. Similarly, workers injected with  $^3\text{H}$ -24-methylenecholesterol rather than fed it provided some labeled sterol to the brood. Thus  $^3\text{H}$ -24-methylenecholesterol was transferred to the nutrient from endogenous pools of both the "dark" workers and the injected workers. (Cooperative research with Dr. E. W. Herbert, Jr., Bioenvironmental Bee Laboratory, PPI).

Phytosterol converted to cholesterol in yellow fever mosquito larvae - Beltsville, Maryland. The fate of  $^{14}\text{C}$ -sitosterol fed to yellow fever mosquito larvae has been examined. Over 40% of the recovered radioactivity from pupal sterols was associated with cholesterol, unequivocally showing that this C<sub>29</sub> phytosterol was converted to cholesterol. This is the first conclusive proof that a dipterous species can dealkylate a phytosterol and convert it to cholesterol. Preliminary studies with certain other dietary sterols (campesterol and desmosterol) indicate that the metabolic pathway for this conversion in this insect is similar to that found in most other species capable of it.

First indication of regulatory component controlling ecdysone 20-monooxygenase - Beltsville, Maryland. Two enzyme systems have been found in the midgut of the tobacco hornworm that convert ecdysone to 20-hydroxyecdysone, the most active molting hormone: one in the mitochondria and one in the microsomes. The two enzyme systems have been shown to act independently and do not synergize or inhibit each other. Certain experimental conditions reduce the enzyme activity of the mitochondria, apparently through the loss of a soluble component; this response can be prevented by addition of bovine serum albumin. This is the first indication of a regulatory factor controlling the activity of ecdysone 20-monooxygenase.

Inhibition of molting in milkweed bug - Beltsville, Maryland. 2-acetylpyridine thiosemicarbazones have been found to inhibit molting in Oncopeltus at 1  $\mu\text{g}/\text{nymph}$ . These compounds reduce ecdysteroid levels in 5th-instar nymphs and delay the peak of ecdysteroid production.

Makisterone A, the principal molting hormone in milkweed bug nymphs - Beltsville, Maryland. In 1975 makisterone A was found in the embryos of Oncopeltus. In follow up studies the injection of makisterone A into adult females has been found to induce molting and to inhibit egg development. Also HPLC and RIA studies show that makisterone A or a very similar compound is the major ecdysteroid in the hemolymph of last-instar nymphs. Makisterone A has been much more effective than 20-hydroxy ecdysone in inducing molting in last-instar nymphs.

Inhibition of juvenile hormone esterase and ecdysone oxidase by means of diflubenzuron - Fargo, North Dakota. Low doses of diflubenzuron applied to boll weevil pupae yield pupal-adult intermediates. These intermediates indicate a hormonal imbalance. In vitro analysis of the soluble fraction of the whole-body boll weevil homogenates shows that diflubenzuron inhibits enzymatic degradation of juvenile hormone I and of  $\alpha$ -naphthyl acetate. The half-life of juvenile hormone I applied to young pupae is increased from 65 min to more than

3 h by diflubenzuron. Diflubenzuron also interferes with the action of 20-hydroxy-ecdysone topically applied to pupae.

Falling ecdysone levels trigger release of sperm from testes of Mediterranean flour moth - Fargo, North Dakota. Earlier work has shown that injection of beta ecdysone (1 µg or more) temporarily (1 day) stops release of eupyrene sperm from the testes of pharate adult or adult moths. Moths continue to release apyrene sperm. More recent tests show that the effect of the ecdysone is quantitative. A highly significant reduction in the number of eupyrene bundles released has been found with dosages as low as 10 ng; at lower dosages some eupyrene sperm are released from testes of almost all males. No counts have been made of apyrene bundles, but observations suggest that treated males release fewer bundles than control males. Ecdysone has been found to have a more pronounced and longer-lasting effect in isolated abdomens than in whole moths. Isolation of adult abdomens as such has almost no effect on the quantity of sperm released from the testes, but injection of 1 µg of beta ecdysone into abdomens has permanently halted release of eupyrene sperm in some males, with only gradual resumption in others. Release of apyrene sperm continues in most males, but on the day after treatment the quantity is very small compared with that of controls. Treatment of neither whole moths nor abdomens has shown any effect on the normal periodicity of sperm movement from the testes or out of the most proximal segment of the upper vasa deferentia. The work supports the hypothesis that the decline of ecdysone levels, coincident with completion of the accessory asexual organs towards the end of metamorphosis, acts as a metabolic switch, leading to autolysis of the cyst cells of the more advanced sperm bundles and the movement of bundles out of the testes.

Female accessory gland material not involved in fertilization of tobacco budworm - Fargo, North Dakota. Newly emerged females (0-24 h) have been mated to 2-day-old males and allowed to oviposit for 2 consecutive nights. On the third day, accessory reproductive glands are dissected from females that lay > 100 egg/night (indicating a properly inseminated female). The females are then allowed to oviposit for 2-3 additional nights. Hatchability of eggs from glandless females has been high (> 60%) in 5 of the 6 individuals tested, indicating that accessory glands are not involved in the fertilization process.

Boll weevil strain selected from increased survival after sterilization with gamma rays - Fargo, North Dakota. A specially constructed, broad-based synthetic population of boll weevils underwent selection 14 days after 10,000 rads of gamma-ray irradiation. Both survivors and the original population were maintained on a 49-day generation cycle to the 8th generation. Generation 8 of the selected population has been compared for postirradiation survival and half life (age when half the group is dead) with the unselected controls from the base population. The two populations differ by 42.4% for 14-day survival, which compares with a 20.7% difference in generation 4. The half-life difference of 4.1 days compares with a difference of 2.5 days for generation 4. In the early generations the selection response is apparently greater in females than males, but it is not true by generation 8. At this stage of the study we conclude that the effects of selection or inbreeding levels on reproductive performance have apparently not influenced family size, sterility, or adult-to-egg survival.

Ovarian hormone induces pheromone synthesis in house flies - Fargo, North Dakota (in cooperation with University of Nevada). The hydrocarbon profile has been determined for flies at each stage of oogenesis, and the pheromone ( $Z$ )-9-tricosene has not been found before stage 4. After stage 4, the pheromone is produced throughout the remainder of the life of the flies. Ovariectomy of flies within 24 hours of emergence has resulted in the complete absence of pheromone production. Ovariectomy of flies after oviposition does affect ( $Z$ )-9-tricosene synthesis. When ovaries from 12-hour-old donors are implanted into flies that are ovariectomized at 24 hours and then held for 4 days after implanting, pheromone is synthesized. All implants reach stage 4 or 6 of development, and these flies have the same hydrocarbon pattern as a control fly with stage-4 ovaries. Ring gland ablation or allatectomy has no effect on pheromone production because their ovaries develop to stage 4. Furthermore, ecdysone injections into ovariectomized flies do not turn on pheromone synthesis. Thus, a hormone other than ecdysone from stage-4 ovaries stimulates the female fly to produce pheromone. This is the first time that an ovarian hormone has been shown to trigger pheromone synthesis in any insect.

Storage of uric acid in the fat body induced by 20-hydroxyecdysone in the absence of juvenile hormone - Fargo, North Dakota. The last larval instar of M. sexta switches from excreting uric acid to storing it in fat bodies during transition from the feeding to the wandering stage. Larvae selected 32-36 h before initiation of wandering have been ligated between the meso- and metathoracic segments and held for 48 h at 25°C. During this time, no increase in fat-body uric acid has been observed, but uric acid concentration in fat bodies of nonligated larvae increases from 5 to 200 nmoles/mg dry weight. Uric acid levels in fat bodies of ligated larvae injected with 20-hydroxyecdysone are 20-100 fold higher than those in fat bodies of saline-injected controls. Effects of 20-hydroxyecdysone are reversed (80%) by juvenile hormone (JH) applied topically.

These experiments clearly show that 20-hydroxyecdysone induces uric acid storage but only in the absence of JH. This hormonally controlled switch from excretion to storage in fat body allows the animal to sequester large quantities of nitrogenous waste while maintaining low levels in the blood during pupal and adult development.

Technological Objective 2: Develop new and improved principles and practices of insect control based on behavior and ecology.

#### Research Locations:

Albany, California  
Gainesville, Florida  
Beltsville, Maryland  
Otis AFB, Massachusetts  
Fargo, North Dakota  
Wyndmoor, Pennsylvania  
Yakima, Washington

Some examples of recent progress are:

Attractants of alfalfa seed chalcid isolated from alfalfa leaves and stems - Albany, California and Corvallis, Oregon. 1-octen-3-ol betacyclocitrol, (E)-beta-ocinene, and hexanol are important components of the blend that attracts the alfalfa seed chalcid.

Preferential greenbug feeding on phloem of susceptible sorghum plants and other tissues of resistant plants - Albany, California. Electronic monitoring of the feeding behavior of biotype-C greenbugs indicates that they cannot feed in the phloem of resistant sorghums. A physical barrier is not involved, and thus the resistance mechanism may be feeding deterrent present in the phloem sap.

Growth of tomato fruitworm reduced by tomato foliage constituents - Albany, California. Tomatine, rutin chlorogenic acid, and a new caffeyl derivative isolated from tomato foliage have been found to inhibit growth of tomato fruitworm larvae.

Analytical method for condensed tannin improved - Albany, California. A more accurate and reproducible analytical procedure has been devised for hydrolyzing condensed tannin in the presence of polyamide. These conditions improve the stability of the red anthocyanidin color.

Sex pheromone of beet armyworm identified - Gainesville, Florida. The sex pheromone produced by the female beet armyworm has been isolated and identified. When used in traps in the field, two components, (Z,E)-9,12-tetradecadien-1-ol acetate and Z-9-tetradecenol, are equal to live females in capturing wild males of this species. This pheromone can be very useful in monitoring and controlling this important pest, and information gained in this study can be applied to the investigation of the pheromones of other important species in the armyworm pest complex.

Western corn rootworm sex pheromone identified and synthesized - Gainesville, Florida with the USDA SEA-AR Northern Grain Insects Research Laboratory, Brookings, SD. The sex pheromone produced by female western corn rootworms (WCR) has been identified as 8-methyl-2-decanol propanoate. The synthesized compound has been highly attractive to wild male WCR in field trapping experiments. This is the first pheromone identified from the insect family Chrysomelidae. The accuracy of monitoring programs for this pest can be greatly increased by the use of this pheromone, and thus the amount of pesticides applied for control in the Midwest can be significantly reduced. This may result in immediate savings to farmers and in positive environmental effects. This pheromone may also be useful in IPM programs designed to control WCR.

Resolution of complex pheromone mixtures through capillary gas chromatography columns with new liquid crystals - Gainesville, Florida. New liquid crystals have been synthesized and coated onto glass-capillary gas chromatography columns that are capable of completely resolving previously inseparable, complex pheromone mixtures. The liquid crystal columns complement columns coated with polar phases, which had previously been developed in this laboratory. Thus the four isomers of the navel orangeworm pheromone have been completely

resolved for the first time, making it possible to distinguish naturally produced and synthetic pheromones. Similarly, these columns make possible the accurate analysis and identification of complex pheromone mixtures of several Heliothis species. These columns can be extremely valuable in the identification of other pheromones and in the determination of exact isomeric ratios in previously identified pheromone blends. This knowledge is crucial for the understanding of insect behavior and design of effective insect monitoring and control systems.

Pheromone-mediated behavior of *Heliothis virescens* and *H. subflexa* defined and elucidated - Gainesville, Florida. The responses of *H. virescens* and *H. subflexa* males to females of both species and to various glandular extracts have been analyzed in wind tunnel bioassays. Responses to conspecific and other-species females are distinctive, and behaviors are also significantly changed when moths are presented extracts of less than the total pheromone-producing glandular apparatus. Additionally, the sex pheromone of *H. subflexa* females has been identified and carefully defined as a blend of Z-9- and Z-11-hexadecenal, and Z-7-, Z-9-, and Z-11-hexadecenyl acetate. The acetates are unique to *Heliothis* species thus far and contribute to species isolation. The knowledge gained in this investigation considerably increases our understanding of the pheromone-mediated behavior of *Heliothis* species and may significantly influence current programs that use mating disruption and sterile hybrid control.

Multi-kilogram process developed for synthesizing (Z,E)-9,12-tetradecadien-1-ol acetate - Gainesville, Florida (in cooperation with Zoecon, Corp.). A practical process has been developed for preparation of high-purity (Z,E)-9,12-tetradecadien-1-ol acetate (ZETA) and the corresponding alcohol on a multi-kilogram scale. An estimate of materials and labor costs indicates that this process can significantly reduce the cost of commercial synthesis of this pheromone. ZETA is a key component in the pheromone of the beet armyworm and other important armyworm species and in the pheromones of several lepidopteran stored-product pests, including the Indian meal moth.

Identification of factors responsible for decline in visual sensitivity of mass-reared medflies - Gainesville, Florida. Quality factors in various wild and laboratory-reared populations of medflies have been studied over several years. The following factors have been associated with decline in visual sensitivity and, often, with decline in other indices of quality: genetic filtering, high-density rearing, dietary deficiencies, handling procedures, pupal irradiation, and high-density shipping.

Parasitism not adversely affected by application of tobacco budworm pheromone in tobacco - Gainesville, Florida. Levels that tobacco budworm larvae parasitize preharvest tobacco treated with synthetic pheromone for mating disruption are statistically equal to those of corresponding untreated controls. Over 50% of the budworm larvae collected in April were parasites. This information is important in the development of IPM programs for tobacco and possibly other crops that the tobacco budworm parasitize.

Pheromone traps useful in predicting potential economic infestations of tobacco budworm - Gainesville, Florida. For the third consecutive year, correlations were significant among trap catches of tobacco budworm males, larval infestations, and damage levels in tobacco, including fields treated with synthetic pheromone for disruption of tobacco budworms. Significant correlations occurred within intervals that decreased as daily mean temperatures increased. This information is important in the development of a predictive model for tobacco budworm populations.

Inexpensive pheromone analogs of corn earworms - Gainesville, Florida. Two chemicals, (*Z*)-11-hexadecen-1-ol acetate and (*Z*)-1,12-heptadecadiene, have been found to interfere with the sex pheromone communication of corn earworms. These chemicals are more stable than the aldehydes that comprise the natural pheromone, and the diolefin is less expensive to manufacture.

Control of fall armyworm reproduction with pheromone possible for large and small farmers alike - Gainesville, Florida. Control of insect pests by permeation of the atmosphere with chemicals that disrupt sexual communication is receiving attention worldwide from both the public and private sectors. This unique application of what are now generally recognized as environmentally safe compounds offers an opportunity to develop rational integrated control programs for a wide range of insect pests in a variety of cropping situations.

In recent field experiments at Gainesville, mating and oviposition by the fall armyworm in corn have been reduced 86 and 84%, respectively, with application of one component of the sex pheromone. This achievement is remarkable, because the test field is only 30 acres in size and it is surrounded by corn and other hosts of the fall armyworm. These results indicate that the air-permeation technique can be used to suppress reproduction of pest insects in areas much smaller than heretofore predicted. Hence, the technology can be more easily integrated into insect control programs on a much smaller scale than previously believed--perhaps to 100 acres or less.

Synthetic pheromone effective in disrupting sexual communication of tobacco budworm in tobacco - Gainesville, Florida. Captures of tobacco budworm males in pheromone-baited traps were greatly reduced in pheromone-treated fields, and these fields required fewer (25-60%) conventional insecticide treatments than corresponding control fields. However, insecticide treatments were required for tobacco hornworms and stinkbugs in the pheromone-treated fields. This information indicates that the air permeation technique may be limited as an economic control of tobacco budworms until similar remedies are available for the tobacco hornworm and possibly other pest species.

Guidelines for the use of data on spectral sensitivity and reflectance in the selection of color traps for insects - Gainesville, Florida. Trap colors can be selected with a knowledge of the spectral sensitivity of the insect being trapped and the spectral reflectance of its normal host, i.e., colors that are important to the insect and that the eye of the insect is sensitive to. Reflectance in the UV region is important in attracting species associated with vertebrate hosts. Fruit-seeking insects do not respond to UV wavelengths but do respond to wavelengths that reflect at about the 50% level and occur about midway

between the insect's peak sensitivity in the green-yellow region and its sensitivity cut-off in the red region. Final selection of the most effective trap color may of course, be aided by feedback from additional field data on trap preference.

Technique devised for identifying sterile hybrid budworms - Gainesville, Florida.

Continuous backcrossing of Heliothis virescens males to female hybrids of the cross H. virescens males x H. subflexa females allows backcross hybrids to be studied for their potential in controlling H. virescens populations. Within a few generations the backcrossing gives a hybrid population that is almost identical to H. virescens genetically. This has thwarted efforts to apply standard biochemical techniques to the problem of differentiating the two types, a necessity for determining their relative abundance in field suppression studies. This problem has been solved by biochemical analysis of the mitochondrial DNA, which, if properly treated, yields a straightforward diagnosis of the differences between the hybrid and H. virescens. Mitochondrial DNA is maternally inherited intact from H. subflexa and thus is different in its nucleotide sequence from DNA donated by H. virescens males.

Isoenzyme analysis of origin of recent medfly introduction in California - Gainesville, Florida. The origin of the recent outbreak of Mediterranean fruit flies in San Jose, California, is of interest to regulatory authorities. We have used the isoenzyme technique to compare data on the genetic structure of this population with similar data on populations from throughout the world. One genetic allele present in the California population has not been found in the Hawaiian population. This makes it unlikely that the flies introduced into California originated in Hawaii. This allele has, however, been found in Central American populations, making that area a likely source of the introduction. Similar reasoning leads us to suspect that the Central American population, introduced in 1955, originated somewhere other than Hawaii.

Methyl  $\alpha$ -eleostearate as a boll-weevil feeding deterrent - Beltsville, Maryland.

$\alpha$ -Eleostearic acid, the major boll-weevil feeding deterrent isolated from tung last year, has proved to be quite unstable. The methyl ester of the acid has proved to be even more effective as a boll-weevil feeding deterrent and much more stable than the free acid. This compound has been found to be nontoxic to laboratory animals, noncarcinogenic to microorganisms, and nonphytotoxic. Applications have been made for two public-service patents, one on the boll-weevil feeding detergency itself and one on the preparation of methyl  $\alpha$ -eleostearate and erythro-9,10-dihydroxyoctadecan-1-ol acetate (isolation reported last year). An industrial firm is preparing to develop and market the methyl ester (named "Bollex") under exclusive license with USDA. Field tests with "Bollex," conducted by USDA's Boll Weevil Research Laboratory and by an independent laboratory, indicated that the formulation effectively reduces boll weevil damage to cotton plants. A method has been developed for isolation of half a gallon of pure  $\alpha$ -eleostearic acid from 1 gallon of tung oil (available for \$10) and for its quantitative conversion to its methyl ester. Specifications have been drawn up for the commercial synthesis of the ester, and spectroscopic analyses have been developed for its determination in antifeedant formulations.

Hair-pencil pheromone identified for tobacco budworm - Beltsville, Maryland.  
A pheromone has been isolated from an ether rinse of nearly 20,000 virgin male hair pencils. Field studies conducted in cooperation with the USDA Tobacco Research Laboratory, Oxford, NC., show that the hair-pencil pheromone repels other males in nature.

Host attractants of tropical fruit flies identified - Beltsville, Maryland  
(in cooperation with the Tropical Fruit and Vegetable Laboratory, Honolulu, HI). The attractant for male Mediterranean fruit flies that occurs naturally in tangerine peel oil has been isolated and identified as (+)-limonene. Methyl linoleate and methyl linolenate have also been identified in that fraction of the green coffee-berry extract that is highly attractive to female melon flies and female Mediterranean fruit flies.

Antifeedant in seeds of Indian custard apple - Beltsville, Maryland.  
The seeds of Indian custard apple (Annona squamosa) and A. reticulata contain an as yet unidentified, highly polar ester that is an antifeedant of the fall armyworm and is highly toxic to the large milkweed bug. When the substance is incorporated into the rearing diet, at 100 ppm, the average weight of fall armyworm larvae is less than 1 mg after 7 days; untreated larvae average 129.4 mg. The active component caused 100% mortality in the milkweed bug when applied to nymphs at 0.1 µg. It did not affect yellow mealworm larvae.

Sex attractants identified for four moth species - Beltsville, Maryland.  
Sex-attractant pheromones of female moths have been identified for four species: the Asian corn borer, Ostrinia furnicalis; the artichoke plume moth, Platypilia carduidactyla; Heliothis subflexa; and the cranberry fireworm, Choristoneura parallela. Synthetic mixtures are as attractive as the respective females.

The artichoke plume moth is the major insect pest in artichokes. The synthetic pheromone can now be used to detect infestations and may be used to suppress pest populations by mating disruption.

Gypsy moth mating strongly suppressed by racemic disparlure formulated in plastic flakes - Beltsville, Maryland. Racemic disparlure formulated in plastic flakes has been aerially applied to forest plots to establish the parameters governing disruption of gypsy moth mating by pheromone permeating the air. Doses evaluated were 0, 3, 12, and 30 g/acre. Population pressure varies over four plots for each dose. Disruption of mating communication was assessed with trap catches normalized against population pressure in treated vs. control plots. Actual mating suppression was measured with sentinel females (lab-reared, wild, and feral). A strong, positive dose-response has been seen for all female types and for trap catch. The translation of mating communication disruption into actual mating disruption is mediated by two parameters, i.e., the achieved level of communication disruption and the population pressure.

Adjuvants to gypsy moth virus - Otis AFB, Massachusetts. Although technology has been developed for mass producing the gypsy moth virus at low cost, problems with low pathogenicity and persistence in the field have curtailed its use as a biological insecticide. Efforts have been increased to improve the formulation technology affecting virulence and persistence. A number of adjuvants

have been tested in standardized bioassays, and some have given encouraging results. COAX®, a commercially available adjuvant used in Heliothis virus formulations, has been found to increase the effectiveness of gypsy moth virus 2-3 fold. Boric acid (1%) increases virus-induced mortality as much as 9 fold. Of several commercial sunscreens tested for protection against sunlight inactivation of virus, EUSOLEX 232® has been effective and is being further tested on red oak foliage. The use of these compounds as adjuvants in virus formulations may facilitate the use of the virus as a practical alternative for controlling the gypsy moth.

Procedures developed to rear sunflower stem weevils - Fargo, North Dakota.

The stem weevil, Cylindrocopturus adspersus, has been successfully maintained throughout the year in an environment controlled for the mature larval stage of a field-collected population. Vigorous adults have been obtained as needed, and mating and oviposition have been achieved in the presence of host plant material. An artificial diet has been developed that produces full-grown vigorous stem weevils. The presence of the host plant is still needed for oviposition and a high mating frequency.

Tobacco budworm females begin egg laying at 3 h after onset of darkness and begin mating at 4 h after onset of darkness - Fargo, North Dakota. Optimum mating and oviposition periods have been determined for H. virescens males and females reared and held under reversed light-dark regimes. Two-day-old males reared under a reversed 14:10 LD cycle were paired individually with newly emerged (0-24-h-old) females reared under similar conditions. Moths were paired during the light cycle. Individual cages were examined every  $\frac{1}{2}$  h after the start of the dark cycle under a low intensity red light; moths in copula were removed and the time was recorded. Over 75% of the matings occur between 3-1/2 and 5 h after the onset of the dark cycle, with only about 7% of the matings taking place after 6 h. Peak mating occurs at about 4 h. No mating takes place earlier than 3 h after the onset of darkness. The peak ovipositional period occurs slightly earlier than the peak mating period. Most eggs are laid between 3 and 4 h after the onset of darkness; however, some females tend to deposit large clusters of eggs shortly before the end of the dark cycle (9-10 h after the onset of darkness). Thus native females under natural conditions probably lay eggs early in the evening and remate shortly thereafter.

Symbiotic relationship of screwworm and the bacterium, Proteus rettgeri - Fargo, North Dakota. Proteus species have been found in screwworm larvae and pupae as well as in various larval feeding media, including fluids from screwworm-infested animals. In more than 50 isolations from laboratory and field samples obtained in Texas, North Dakota, and Mexico, combinations of Proteus mirabilis, P. vulgaris, P. morganii, P. rettgeri, and P. inconstans were detected. All Proteus species were found in a given sample and different ones predominated in different samples, but at least one Proteus sp. was consistently present. In laboratory olfactometer tests, bacterial cultures of P. rettgeri attracted up to 80% of mated female flies, depending on the dilution of the inoculated broth. Proteus rettgeri has been isolated in pure

culture from larval salivary glands, pupae, and wounds with screwworm larvae. Preliminary electron microscopic examination suggests that Proteus bacteria may weaken the puparium, thus helping adult screwworm flies emerge.

Antibacterial effect of *Proteus mirabilis* on gram positive and gram negative bacteria - Fargo, North Dakota. Bactericidal activity has been found in the filtrate of Proteus mirabilis isolated from screwworm fly larvae. The activity of this filtrate is inversely proportional to the pH. Greatest activity is found at pH 2.5, gradually decreasing until it is lost at pH 4.5. If the pH of an alkaline sample is returned to pH 2.5, the bactericidal activity resumes. Salmonella typhimurium, Proteus mirabilis, and Staphylococcus epidermidis are highly susceptible to the filtrate. A 1-min exposure to pH 2.5 filtrate produces a 99.98%, 99.99%, and 99.97% decrease in these populations respectively. Proteus rettgeri is more resistant than these three to the filtrate, since a 1-min exposure to pH 2.5 filtrate results in only a 12% decrease in population.

Procedure for trapping volatile compounds emanating from intact plants - Wyndmoor, Pennsylvania. A procedure for trapping volatile compounds emanating from intact plants has been developed. Plants are placed in a chamber, and volatiles are trapped by withdrawing atmosphere from the chamber through a tube packed with a porous polymer absorbent, Tenax. Volatile compounds can be desorbed from the porous polymer if the tube is heated and an inert gas is passed through it. Volatiles can be retrapped directly on the head of a cooled gas-liquid chromatographic column for separation and identification.

Optimum trap placement and pheromone dose defined for the filbertworm in Oregon and California - Yakima, Washington. In Oregon pheromone traps baited with 0.16 or 0.64 mg/septum of lure have caught significantly more male moths than traps with lower doses. Also, traps placed at 12 ft. levels in the interior of the trees have captured significantly more moths than traps placed at 6 ft. and 9 ft. levels. In similar studies conducted in pomegranate orchards in central California, where this insect has recently become a very serious pest, traps with concentrations of 0.64 mg/septum of lure positioned at 8 ft. have caught significantly more moths than traps with lesser concentrations positioned at 6 or 4 ft. levels.

Sex pheromone of the citrus cutworm identified - Yakima, Washington. The citrus cutworm, Xylomyges curialis, is a pest of citrus in California. A newly identified pheromone attracts males when the formulation is placed in the field.

New method for determining half-life of pheromone formulations - Yakima, Washington. The half-lives of formulations as long as 700 days can be determined in about 4 h. Vapors are collected on reverse-phase liquid chromatographic support, extracted, and analyzed by gas chromatography. The data are evaluated by means of recently developed equations and principles. This approach allows extensive testing of formulations of various pheromones, including aldehydes, and the quantitative determination of the effects of formulation parameters, wind speed, and temperature on evaporation rate.

Technological Objective 3: Develop new principles and practices in insecticide use.

Research Locations:

Beltsville, Maryland  
Yakima, Washington

Some examples of recent progress are:

Fifty-two new candidate chemicals for insect control - Beltsville, Maryland.

Fifteen industrial laboratories have submitted 68 samples of 52 new chemicals for cooperative evaluation in AR laboratories as candidates for insect control. The number and potential of new chemicals from industry have continued to decline. Of the 52 received, 24 are targeted for tests against fire ants; of the remainder, the principal class is miscellaneous heterocycles (11), followed by pyrethroids (6), organophosphates and carbamates (5), ureides (3), and miscellaneous (4). A new product of macrocyclic fermentation is effective against animal parasites at low dosage.

Information on Wiswesser line notations (WLN's) for chemicals evaluated for insect control now available - Beltsville, Maryland. Line notations for chemical structures are now put into a computer system on a current basis. The tape file, available through the Technical Information Systems, can be used to search for known active and related compounds. This enables scientists to identify groups of related compounds for comparison of results or guidance on further research.

Environmental chemical dissipation file - Beltsville, Maryland. In cooperation with the Pesticide Degradation Laboratory, AEQI, a file of data on dissipation of environmental residues has been established.

Infrared spectrometer adapted for rapid analysis of various pesticides - Beltsville, Maryland. A Fourier Transform IR Spectrometer fitted with a liquid chromatograph (LC) and a flow cell has been tested for use as an LC detector for pesticides. Excellent chromatographic separation of pesticide mixtures (e.g., aldicarb, dimilin, and carbaryl) has been obtained with a CN column and a carbon-tetrachloride mobile phase. Complete IR spectra of pesticides has been obtained on-the-fly during LC with 500 µg or more of sample. This sample size is adequate for formulation analysis, but it must be improved by a factor of 100 for residue analysis.

Quantities of pesticides at the nanogram level can be quantitated with voltammetric detector - Beltsville, Maryland. The ability of the voltammetric detector to detect multiple pesticide residues has been evaluated. It has been found that nanogram quantities of parathion, methyl parathion, glyphosate, 2,4-D, carbofuran, 3-hydroxy and 3-keto carbofuran can be quantitated.

Little, if any, terramycin transferred to honey by medicated bees - Beltsville, Maryland. Spectrofluorometric measurements have been taken of amounts of terramycin present in honey from capped cells of honey bee colonies treated with medicated syrup sprays, sugar dusts, and extender patties. Preliminary

findings show that a substantial portion of the terramycin is not transferred into the stored honey.

A number of repellents evaluated for environmental hazard - Beltsville, Maryland. Fifteen promising repellents have been synthesized and purified for preliminary hazard evaluation at the U.S. Army Environmental Hygiene Agency, Aberdeen, Maryland. Two kilograms each of two most promising repellents have been synthesized to a very high state of purity for ongoing advanced toxicological testing.

Some candidate repellents more effective than deet against blackflies and Phlebotomus papatasi - Beltsville, Maryland. The Insects Affecting Man Laboratory has received 126 new candidate repellents. Additional quantities of 38 promising repellents have been supplied for field tests and for secondary repellency tests. In tests against Phlebotomus papatasi in Panama and against various blackfly species in the Amazon, a number of candidate repellents have proved to be more effective than deet.

Repellents show promise as "mothproofing agents" - Beltsville, Maryland. Numerous candidate repellents have been synthesized and supplied to the Stored-Products Insects Research and Development Laboratory for biological evaluation. The 1980 data have been received for 161 chemicals evaluated as "mothproofing agents" against black carpet beetle larvae; 40 provide satisfactory protection at both the 0.5 and 3.0% test levels.

Three new compounds show promise as fumigants for fruit or cereal products - Beltsville, Maryland. Larvae of Caribbean fruit fly, Anastrepha suspensa, were fumigated with either of two cyclopropyl compounds. They formed puparia, but adults did not emerge from them. One of these compounds has killed apple maggots, Rhagoletis pomonella, without damaging the fumigated fruit. An unrelated compound, 3-butyn-2-one, has shown toxicity as a fumigant against larvae of the Indian meal moth, Plodia interpunctella.

New method for obtaining wild flies for insecticide testing - Beltsville, Maryland. A method has been found for collecting horse flies alive in the field and transferring them to surfaces coated with toxic residues.

During the 1980 horse-fly season (June through September) eight new insecticides were tested by releasing 25-50 flies into a 1 ft<sup>3</sup> cage with a glass surface coated with a toxicant. The flies were attracted to the treated surface via positive phototropism. After 5-30 min the glass surface was replaced by clean glass. AI3-29559 was the outstanding insecticide of the season: 100% kill after 50 h of continuous exposure to germicidal UV radiation. Permethrin and fenvalerate were 100% effective with 5 min exposure to 10 mg/ft<sup>2</sup>; sumithrin, Orthene®, and Lannate® were 100% effective after 10 min exposure; and AI3-29472c, AI3-29473, and AI3-29603a required 30 min exposure to give 85-100% kill.

UV in evaluations of surfaces and substances toxic to face flies - Beltsville, Maryland. Toxic surfaces have been tested for control of the face fly. The species is positively phototactic and responds to concentrated UV radiation.

With this method treated filter paper is placed between the flies and a source of UV radiation (BLB fluorescent lamp); the flies remain on the filter paper (tarsal contact) for 1-5 min. The flies can be removed from the paper by removing the UV source, because they follow the UV radiation. Cypermethrin is the best insecticide tested against face flies by this method. Cypermethrin compound is solar stable and is recommended for experimental field control studies.

Biodegradable implants for cattle grubs - Beltsville, Maryland.

Subcutaneous implants have been used to deliver methoprene, a systemic insect growth regulator (IGR), into the bloodstream of cattle at a controlled rate. Two types of implants have been employed, biodegradable pellets and reservoir devices. Both systems achieved 100% control of cattle grubs. The polymeric carrier matrix of the pellets is completely absorbed by the animal after several months.

Residues of systemic insecticides found in leafcutter bee environment -

Yakima, Washington. In the Pacific Northwest leafcutter bees are necessary for pollinating alfalfa grown for seed production. In recent years the vigor of the bees appears to be declining and mortality has been high. The possible role of systemic insecticides in this syndrome is being investigated. Residues of aldicarb, demeton, Dylox®, carbofuron, and Cygon® have been found in bee cells.

Aldicarb persists in certain soils for 450 days - Yakima, Washington.

Analysis of soil samples shows that significant residues of aldicarb can persist for 450 days and contaminate crops planted in the following year. Residues of aldicarb have thus been found in leaves of potatoes planted 1 year after application of aldicarb to soil.

PUBLICATIONS

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## BIOLOGICAL AGENTS FOR PEST CONTROL

Technological Objective 1: New and improved technology for discovery and evaluation of parasites, predators, antagonists, and pathogens in foreign countries and for introduction and utilization of natural enemies for control of insects, weeds, plant pathogens, and other pests.

NPS Contact: J. J. Drea, Jr.

Research Locations:

Hurlingham, Argentina  
 Albany, California  
 Newark, Delaware  
 Gainesville, Florida  
 Sevres, France  
 Rome, Italy

Sapporo, Japan  
 Beltsville, Maryland  
 Frederick, Maryland  
 Columbia, Missouri  
 Temple, Texas

Examples of Recent Progress:

New and promising candidate weed-feeding insects found for control of rangeland weed pests in Southwest - Hurlingham, Argentina, and Temple, Texas. In Argentina stem-boring insects were found attacking bitterweed (Hymenoxys), cerambycid beetles were found boring in stems and roots of tarbush (Flourensia) and creosotebush (Larrea), and larvae of buprestid beetles have been found infesting stems of whitebrush (Aloysia). These new discoveries are promising candidates for introduction. In the U.S., a system was devised for prioritizing different weeds for their biocontrol potential, a new species of insect was found attacking bitterweed, stem-boring insects were found for the first time in Baccharis, and natural insect populations were measured on other target weeds.

Musk thistle declines due to weevil activity - Albany, California. The seed head weevil, Rhinocyllus conicus, first released in 1969 in Virginia and Montana and later distributed to over a dozen States, is continuing to cause a decline in the density of musk thistle (Carduus thoermeri and C. macrocephalus) and shows promise as a major success. Over 15,000 eggs of Trichosirocalus horridus, a weevil that attacks the crown of musk thistle, were shipped to six States to add pressure to this weed.

New beetles released against leafy spurge and diffuse knapweed - Albany, California. Oberea erythrocephala, a recently cleared species of beetle, was released against leafy spurge in the Northern Plains States. In the Pacific Northwest, the root boring beetle, Sphenoptera jugoslavica, was released against diffuse knapweed. Both target plant hosts are serious pests of range and pasture areas.

Introductions of exotic natural enemies for biological control - Newark, Delaware. During 1980, the Newark quarantine facility processed 98 lots of foreign insects, about 145,751 organisms from 12 different countries. A total of 33 beneficial species (103,412 specimens) left Newark and were sent in 212 shipments to 48 research workers in 23 different States and 3 foreign countries. From these shipments, at least 21 species of biological control agents were liberated in the U.S.A. against 18 target pests, including various aphids, the

alfalfa blotch leafminer, lygus bugs, greenbug, the birch leafminer, and the larch casebearer.

Partial biological control of alfalfa blotch leafminer attained - Newark, Delaware. Introduced parasites of European origin have reduced populations of the alfalfa blotch leafminer below economic threshold during first cutting of alfalfa. Second cutting has not been protected by parasites, probably because the fly migrates into test fields from surrounding areas where imported parasites have not been established. It is estimated that control of the fly in the Northeast for first cutting alone can result in a savings of \$5-6 million per year.

Computer storage of shipment and release records increased - Newark, Delaware. Computerization of records has facilitated quarantine operation. Records are available for 213 beneficial species of arthropods, representing 5,849 shipments, that have been released over the past 20 years.

Alfalfa weevil parasites continue to reduce damage in the Northeast U.S. - Newark, Delaware. Parasites of the alfalfa weevil continue to spread and increase in northeastern States, resulting in 75-percent reduction of pesticide use in 1980. The estimated saving of \$8 million per year is about eight times the total cost of the project over its 20-yr lifetime.

Large numbers of a nematode were recovered from gypsy moth in France - Sevres, France. More than 800 specimens of Hexameris n.sp. were recovered from larvae of Lymantria dispar collected in central France. This appears to be the first record of this nematode from L. dispar in France. The nematode was sent to the U.S. for study and eventual release against the moth.

Detailed faunistic survey of leafminers of birch and their natural enemies - Sevres, France. The birch leafminers and their natural enemies have been studied in central France. Thirteen species of miners have been discovered, with four species being prominent. The biologies of these principal species were studied. The principal parasites of the first generation are Grypocentrus albipes Ruthe and Lathrolestes nigricollis Thompson.

Establishment in U.S. of Patasson lameerei, a European parasite of eggs of clover weevils, Sitona sp. - Sevres, France, and Newark, Delaware. This establishment, recorded last year as probable, has been confirmed in 1980. If the parasite increases in population density, partial control of the Sitona weevil is likely.

A new insect tested and found promising for control of leafy spurge in the United States - Rome, Italy. A lacebug, Oncochila simplex, was found in northern Italy on leafy spurge, a native to Europe. The lacebug insect severely damages leafy spurge as it feeds on stems and leaves. The insect was tested on other species of plants; it survived only on a few Euphorbia species other than its host. The insect has now been sent into quarantine in the United States, where additional tests may further show the potential of this lacebug insect as a biological control agent of leafy spurge in the United States.

A potential insect for the control of curly dock in the United States was found and tested in Italy - Rome, Italy. A clearwing moth, Pyropteron chrysidiiforme, was found in the larval stage throughout Italy infesting the roots of curly dock, Rumex crispus, and other closely related dock species. Tests conducted in Rome have shown that feeding by the insect is restricted to a group of docks related to curly dock; it is quite damaging to the root of infested plants. Additional screening tests are to be conducted in the United States.

Possible establishment in Connecticut of new predator of gypsy moth from Asia - Sapporo, Japan, and Newark, Delaware. Large numbers of eggs of the predatory bug, Dinorhynchus dybowskii, were collected in Japan. Subsequently, more than 1,000 nymphs of the bug were released in Pennsylvania, Maryland, and Connecticut. Same-season recovery of egg mass of predator in release area indicates possible establishment of the predator.

Nematode parasite of gypsy moth moves up 1.9 m into trees to parasitize host larvae - Sapporo, Japan. Gypsy moth larvae, Lymantria dispar japonica, caged on trees 1.9 m above ground level, have been parasitized by preparasites of the nematode, Hexamermis, which moved from the soil litter and soil up to the branches of the tree.

New natural enemy of corn rootworms found in Peru - Beltsville, Maryland. During explorations near Cuzco, Peru, populations of Diabrotica speciosa, a beetle closely related to the U.S. corn rootworms, were found to be heavily attacked by a parasitic nematode, since identified by USDA nematologist W. R. Nickle as a new species of Hexamermis. Stock of the nematode was successfully imported for culture at USDA's Nematology Laboratory, where it parasitizes southern corn rootworm larvae. Cooperative studies are being conducted to determine the potential of this nematode as a control agent for the rootworms.

True "musk thistle" rediscovered in the U.S. - Beltsville, Maryland. In 1979 a white and pink, relatively small-flowered species of Carduus was discovered at a site near Sparks, Baltimore County, Maryland. This plant has now been identified by M. K. McCarty, ARS, Lincoln, Nebraska, as the true musk thistle, C. nutans, which has not been recorded in the United States since its introduction over 100 years ago. The dominant species of "musk thistle" in the Northeast and Midwest appears to be the larger-flowered C. thoermeri.

Biological control programs and research in the People's Republic of China (P.R.C.) described - Beltsville, Maryland. A comprehensive report of the 26-day visit of the U.S. Biological Control Delegation to the P.R.C. has been prepared for publication. This 200+ page report presents information from the Delegation on biological control programs and other research programs in entomology, plant pathology, and other agriculture areas. The research was observed during visits to Beijing (Peking), Jilin Province in Manchuria, Suzhou, Shanghai, Hangzhou, and Guangzhou (Canton).

Potential parasite for the biological control of the Colorado potato beetle discovered - Columbia, Missouri. An eulophid egg parasite, Edovum puttleri Grissell, a new genus and species, was collected in South America (Colombia) from a chrysomelid species related to the Colorado potato beetle. The parasite was imported and found to readily accept the Colorado potato beetle as a host.

It represents the first known record of an egg parasite of the beetle, and its biological control potential is being investigated.

The use of Stoneville quarantine facilities increased considerably during 1980 - Stoneville, Mississippi. More than 100 shipments of exotic natural enemies from 12 countries of Europe, Asia, South America, and Australia have been processed through the Stoneville Research Quarantine Facility during the year.

Technological Objective 2: New and improved technology for augmentation, manipulation, and conservation of introduced and native parasites, predators, antagonists, and pathogens for control of insects, weeds, plant pathogens, and other pests.

Research Locations:

Tucson, Arizona  
Fresno, California  
Tifton, Georgia  
Peoria, Illinois  
Beltsville, Maryland  
Frederick, Maryland

Stoneville, Mississippi  
Columbia, Missouri  
Ithaca, New York  
Brownsville, Texas  
Temple, Texas

Geocoris spp. reared on artificial diet - Tucson, Arizona. An artificial diet was developed to allow members of the genus, Geocoris, important predators of a number of pests of crops, to complete their development. Refinements of this basic diet are expected to enable the development of systems for rearing the numbers of this predator needed to combat the pests on various crops.

Significant proportions of green lacewing pupae destroyed by a parasite - Tucson, Arizona. Up to 40 percent of the pupae of the green lacewing, Chrysopa carnea, an important predator of a number of crop pests, were parasitized by the wasp, Tetrastichus chrysopae, in alfalfa fields near Tucson. This mortality factor will be of considerable importance if inoculative releases of the lacewings are used to control the pest insects.

The production of noncontaminated baculovirus preparations allow a thorough study of the virology and pathology of this group of viruses - Fresno, California. The RNA virus (TRV) has been biochemically, biophysically, and serologically characterized. The symptomatology and gross pathology in all stages of the cabbage looper have been defined. Both the cabbage looper and a serological technique, the Enzyme Linked Immunosorbant Assay, have been found to be highly sensitive means of detecting the virus. These findings have allowed the production of noncontaminated preparations along with a thorough study of this group.

A nematode offers a safe and effective method for controlling carpenterworm and other Lepidopteran borers in fig and other susceptible trees - Fresno, California. Neoaplectane carpocapsae invasive stages applied with oil cans or pack sprayers in 1:800 or 1:400 w/v water suspension of SG0 592S, a water

absorbent polymer, provide a potentially safe, effective control for carpenterworm larvae attacking fig trees.

Granulosis virus from codling moth has potential for use in IPM systems - Fresno, California. Preliminary field tests indicate a potential use of a granulosis virus infectious to codling moth. The virus is innocuous to beneficial insects and can be incorporated in IPM programs for walnut aphid control.

Dormant oil used as nematode carrier is effective alone for controlling American plum borer larvae - Fresno, California. Undiluted Volck Supreme 2E dormant oil, used as carrier in nematode tests, was applied to active wood galleries. It rapidly penetrated through the accumulated frass and killed the larvae. No phytotoxicity from the limited oil applications was observed.

Extracts of selected host plants increase parasitoid performance - Tifton, Georgia. Characteristics of both the host habitat and host insect influence the search behavior of entomophagous insects. Laboratory and field studies have concentrated on the chemical cues emanating from the trail odors of the host insects (kairomones). These trail odors play a vital role in search behavior, are strongly affected by the host plant species, and can be used to manipulate the field performance of the entomophage. This year, another major advancement was made in the concept of manipulating host search with chemical cues, in that field applications of extracts from certain plants were shown to significantly increase parasitization by released and wild egg and larval parasitoids. These effects were additive to those obtained by host odors when confined applications were made.

Elcar® contains kairomonal activity in laboratory and field studies - Tifton, Georgia. Elcar® at 10,000 ppm has shown kairomonal activity for the parasite, *Microplitis croceipes*, in a standard petri dish bioassay. Field trials corroborate these findings. Elcar® applied to cotton at the recommended 191.9 g/ha rate results in significantly higher densities of the bollworm parasite, *M. croceipes*, *Cardiochiles nigriceps*, and *Apanteles marginiventris* after 24 h. The combined density of parasitoids and major predators is also increased at 96 h post-treatment.

Toxicity of spore-free mutants of *Bacillus thuringiensis* - Peoria, Illinois. Crystals produced by *Spo-* *Cr+* mutants of *B. thuringiensis* were shown to be toxic toward larvae of the European corn borer. The solubilized protein from the crystal is also toxic toward cultured insect cells of the spruce budworm. Mutant toxicity in either case was equal to the toxicity of the parent strain (from which the mutants were derived). These results show that the entomocidal character is conserved in *Spo-* *Cr+* mutants of *B. thuringiensis* and suggest their use as a biological insecticide that avoids the spread of the living agent (the spore).

Characterization of a new spiroplasma - Beltsville, Maryland. The spiroplasma that causes an experimental cataract condition was characterized and given the Latin binomial *Spiroplasma mira*. This is only the second spiroplasma to be identified with a Latin binomial.

Development of growth inhibition serology for determination of spiroplasma species - Beltsville, Maryland. Thirty-four cloned spiroplasma strains were crossed with 18 spiroplasma antisera to determine the level of discrimination of the test. The test discriminates best at the species level and may be an excellent tool in spiroplasma species taxonomy.

Increasing effectiveness of viruses for insect control by proper selection of production methods - Beltsville, Maryland. Significant differences in the virulence of the nuclear polyhedrosis viruses from Autographa californica, Trichoplusia ni, and Heliothis armigera occurred when they were passaged several times in species of insects other than the source species. The differences were greater than 10 fold in some tests. If the correct insect species is chosen for the production of each virus, the levels recommended for use can be adjusted correspondingly, thus reducing the cost to the users.

Histopathology of insect viruses in alternate hosts shows many abnormalities - Beltsville, Maryland. Normal and abnormal viral replication and polyhedral formation occur in passages of two nuclear polyhedrosis viruses through insect species other than the original host species. Both normal and abnormal replications occur within the same tissue. Studies of such abnormal replication provide valuable information on the specificity of these viruses. These studies also help to establish the type of screening procedures required to show the absence of even partial replication of these viruses in non-target animals exposed during treatment of crops for insect control.

Successful development of a serum-free medium for use in insect virus production - Beltsville, Maryland. Animal sera has been a costly but essential component of all insect cell-culture media. Recently, the most frequently used serum has also been in short supply. These problems have been overcome by the development of a complete serum-free medium that supports the growth of gypsy moth cell lines and serial passage of the nuclear ployhedrosis virus. This is a major step forward in the development of commercial, in vitro systems for the production of insect viruses for use in pest control.

Biological control-IPM program effective for cabbage - Columbia, Missouri. A system that relies on regular monitoring of the crop and uses Bacillus thuringiensis (B. t.) when needed for control of three lepidopterans was effective for both the spring and fall crops. The use of B. t. allows maximum suppression by other natural control agents. Six grower locations were involved (35 hectares), and the number of applications of B. t. used this year was ca. one-half the number of applications of chemical pesticides used in previous years.

Colorado potato beetle susceptible to a bacterium - Columbia, Missouri. This is a first record of the susceptibility of this important pest to a bacterium (Bacillus thuringiensis) that is commercially available for controlling caterpillar pests. In laboratory tests a use rate of 1 percent (the average rate recommended for control of caterpillar pests of vegetable and field crops) killed about 60 percent of the Colorado potato beetle larvae.

Single inoculative introductions of virus suppress lepidopteran populations for the entire growing season - Columbia, Missouri. Specific viruses for each of

three pests (Pieris rapae, Plutella xylostella, and Trichoplusia ni) were applied singly when field pest populations reached three to four 3rd-instar larvae/plant for the particular pest species. This single inoculation effectively suppressed the pests for both the spring crop and for a fall crop transplanted into the same field. The yield and quality of the crop were equivalent to yield and quality of commercial cabbage that received five applications of B. t. on the spring plantings and five applications of B. t. in the fall.

Establishment of an insect cell line resistant to baculovirus infection - Columbia, Missouri. An insect cell line resistant to baculovirus infection was established from Spodoptera frugiperda cells. This cell system can be used as a model for studying the resistance of insect cells to baculoviruses and is the first such intentionally produced resistant cell.

A new, safe, effective mosquito control agent - Columbia, Missouri. The bacterium, Bacillus thuringiensis var. israelensis, is a promising microbial insecticide for controlling mosquitoes. Environmental factors such as field temperature, salinity, or pH have little or no direct effect on activity; but pond water sediment and ultraviolet radiation reduce it. However, their effects can be overcome by increasing the use rate.

The predator, Orius insidiosus (Say), has potential as a general biocontrol agent in greenhouses - Columbia, Missouri. Adult and 5th-instar Orius insidiosus (Say) were evaluated as predators of adults and immatures of the two-spotted spider mite, the greenhouse whitefly, and a greenhouse thrip. Orius consumed significant numbers of all three pests. Fifth instars usually consumed more than did adults. Thus, Orius has good potential as a member of a biocontrol complex for integrated control of greenhouse pests.

The culture collection of the Insect Pathology Research Unit (IPRU) is one of the world's largest and most diverse collections of living entomopathogenic fungi - Ithaca, New York. The IPRU has been designated as the prime USDA quarantine laboratory for imported entomogenous fungi. The accession and dispersal activities of the collection are expected to increase to a high level. The IPRU is emerging as a significant international center for diagnosis of entomomyoses. Active involvement in taxonomic research in the Entomophthorales exploits the collection and reinforces the position of the IPRU as a foremost research unit for comprehensive studies of the important pathogens.

Advanced isolation and culture techniques allow detailed lab studies with Entomophaga grylli, a significant natural pathogen of grasshoppers and Locusts - Ithaca, New York. Isolation and culture techniques are easily applied to other fastidious entomopathogens. Basic bioassay techniques have been devised with vegetative cells, conidia, or germinating resting spores. Host range and other studies offer strong experimental evidence for the designation of two subspecies. Evidence has been found for a homothallic sexual life cycle in E. grylli. Field testing with E. grylli should now be both possible and productive in light of the rapid and multifaceted progress with this fungus.

Tetrastichus pretiosum reared on adventitious hosts equal in performance to parasite reared or natural hosts - Stoneville, Mississippi. Field and

laboratory tests showed that parasitism from T. pretiosum mass-reared on the Angoumois grain moth, S. cerealella, processed for release through a programming temperature regime, and then broadcast at high rates in cotton fields is equal to that from T. pretiosum reared on other host species, including a natural host, the tobacco budworm (H. virescens). Consequently, the parasite was released in cotton throughout the summer season and produced a high rate of parasitism of Heliothis. These results form an important base for the pilot test on management of Heliothis spp. in cotton by augmentative releases of Trichogramma to be implemented in 1981.

The reproducibility of activity ratios is an important tool in characterizing the various  $\delta$ -endotoxins produced by B. thuringiensis - Brownsville, Texas. The  $\delta$ -endotoxin activity ratio has been examined more closely and has been shown to be a very reproducible tool. We can distinguish and reproduce the activity ratios in beers of HD-1, HD-241, and HD-263 in a variety of media and under various fermentation conditions. This is encouraging, because it indicates that a type of B. t. produced by a particular isolate will be reproducible.

A method has been developed to analyze the fine structure of  $\delta$ -endotoxin - Brownsville, Texas. Rocket-immunolectrophoresis was used in this method. The results showed that there were differences in the chemical structures of  $\delta$ -endotoxins produced by isolates of a single serotype of B. thuringiensis (var. kurstaki). These differences are well correlated to the spectra of activities of those isolates in Trichoplusia ni and Heliothis virescens.

Relationship between laboratory-derived potencies and field efficacies of B. thuringiensis isolates with different spectra of activities established - Brownsville, Texas. B. thuringiensis isolates with different spectral activities were not equally efficacious when applied to cabbage at the same number of IU's/ha for protection against larvae of the cabbage looper, Trichoplusia ni. Preparations of the isolates were standardized against T. ni larvae. Variety galleriae isolates (HD-196 and HD-153) were the most efficacious/applied IU, and a k-73 type variety kurstaki (HD-73) was the least efficacious/applied IU. A variety thuringiensis (HD-264) and a k-1 type variety kurstaki (HD-1) were intermediate in efficacy/applied IU. Speed of kill and, to some extent, differences in the amount of food consumed appear to be responsible for the differences in efficacy/applied IU. Therefore, when new B. thuringiensis isolates are discovered and developed, the recommended field dosages for the new isolates must be determined by actual field experimentation rather than by extrapolation from existing HD-1 data.

Technological Objective 3: New and improved principles and practices of insect and mite identification to support pest control technologies and other research and action programs in agricultural, biological, and health sciences.

Research Location:

Beltsville, Maryland

Considerable progress in preparing computerized catalog of the Coleoptera of America North of Mexico - Beltsville, Maryland. This catalog is well along,

with three family fascicles published, 15 family sections ready for publication, and 10 family sections being edited. This catalog will enable users to have access to current classification and current names in use in the Coleoptera.

Generic study of fruit flies (Tephritidae) south of the United States completed - Beltsville, Maryland. This revision can be used in conjunction with the neotropical tephritid catalog published in 1967. It provides a means of identifying about two-thirds of the more than 600 species of this economically important family known to occur south of the U.S.

A catalog of Eurasian fruit flies (Tephritidae) completed - Beltsville, Maryland. An up-to-date classification is published for the first time, synthesizing the results of the work of many taxonomists over a long period of time. This catalog facilitates the correct naming of all fruit flies of that region, including the economically important ones.

Keys and descriptions with illustrations for the identification of tachinid flies prepared - Beltsville, Maryland. These keys will help nonspecialists to properly identify two very important groups of parasitic flies, one attacking cutworms and armyworms, the other attacking Heliothis species (including the corn earworm).

Taxonomic study of the genus Palpomyia in North America completed - Beltsville Maryland. Larvae of Palpomyia are commonly encountered by aquatic ecologists. Larvae are effective predators of other small invertebrates and are important components of aquatic ecosystems. Details of their biologies have been little studied because of difficulties in identification. These descriptions and illustrations include immature stages for 31 species with keys for all stages. This publication makes this group available for more intensive study.

Taxonomic analysis of planthopper genera permits recognition of many plant-feeding pests - Beltsville, Maryland. Fifty-one species of the genus Oliarus and 39 species of the genus Cixius have been characterized and described in detail. In the western hemisphere, these insects frequently are collected on damaged crop plants, but the insects' effects have not been studied in any detail. Species in New Zealand and Australia have been implicated as vectors of plant pathogens.

Index for computer-based catalog of Hymenoptera in America North of Mexico published - Beltsville, Maryland. This index provides access to all names, parasites, predators, hosts, and prey and pollen and nectar sources for the 20,000 North American species of destructive and beneficial ants, wasps, bees, and sawflies.

A syllabus covering the identification, classification, and importance of parasitic wasp families completed - Beltsville, Maryland. This important teaching tool contains identification keys, discussion of taxonomic problems, and summaries of biology. It is an integral part of a periodic short course on these important insects.

Identification of the origin of two introduced species of destructive mole crickets in Florida - Beltsville, Maryland. These insects cause 30-50 million

dollars damage yearly in the Southeast. Presently, they cannot be controlled with conventional chemical control, and natural enemies may offer the only hope of control. These studies indicate areas to be searched for natural enemies.

Combined identification manual and encyclopedic treatment of the North American green geometrid moths developed - Beltsville, Maryland. The manual provides access to distinguishing characters of both sexes of these moths for use by APHIS/PPQ area and port identifiers. They are needed to enable rapid separation of the native moth fauna from introduced species, which are potential pests to U.S. agriculture.

Major segments of the National Collection of Insects reorganized to permit accurate and more rapid identification of specimens submitted for determination and to provide the basis for ongoing taxonomic research - Beltsville, Maryland. The last segment of 900 drawers of North American geometrid moths has been organized. More than 100,000 unsorted cutworm moths have been segregated, and about 20,000 specimens have been identified and incorporated into the main collection. The large genus, Euxoa (over 200 species), was properly curated for the first time. Integration into the collection continues with the Painter Collection (46,000 specimens) of Bombyliidae (bee flies) and Asilidae (robber flies) and the Hockett Collection (30,000 specimens) of Muscidae (house flies) and Anthomyiidae (anthomyiid).

Identifications of insects and mites for Federal, State, private, and foreign action and regulatory agencies - Beltsville, Maryland. During CY 80, scientists in the laboratory provided over 25,000 authoritative identifications of nearly 113,000 specimens of pest, beneficial, and non-target insects and mites. These identifications enabled other scientists in ARS, APHIS, FS, State, private, and foreign agencies to conduct research in IPM, biological control, and other insect research. They were also an integral part of APHIS/PPQ's programs for prevention of establishment of exotic pests and for biocontrol of introduced pest species.

Improved techniques developed for biosystematic studies of Trichogramma - Beltsville, Maryland. A slide-mounting technique was developed for permanent preservation of Trichogramma specimens without distortion of important taxonomic characters. Also, a reliable technique for crossing tests was developed for genetic studies. A new species was discovered with this new cross-breeding technique. These new techniques will greatly enhance the Trichogramma biosystematics program.

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National Research Program 20270

CROP DISEASE CONTROL AND NONCOMMODITY RESEARCH  
ON PLANT PATHOGENS AND NEMATODES

Technological Objective 1: Acquire fundamental knowledge and develop basic concepts relative to plant diseases, nematodes, and causal agents.

Technological Objective 2: Develop systems for economical control of plant diseases and nematodes with maximum beneficial effects on yields and quality, and with minimum undesirable effects on the environment and public health.

Protection of crops from the ravages of diseases and nematodes becomes increasingly important as production costs soar. Scientists in this National Research Program study the nature of resistance to diseases and nematodes, how pathogens and nematodes cause damage, and how to improve existing procedures for disease and nematode control and/or management. Research team efforts are designed to develop effective systems for crop production. These systems are designed to implement the most effective combinations of improved resistant varieties, biological control, judicious use of chemicals, and cultural practices. These studies have the ultimate goal of reducing losses in agricultural production caused by diseases and nematodes.

NPS Contact: W. M. Dowler

Research Locations:

Davis, California	Corvallis, Oregon
Salinas, California	Charleston, South Carolina
Shafter, California	Brookings, South Dakota
Miami, Florida	Jackson, Tennessee
Orlando, Florida	College Station, Texas
Byron, Georgia	Lubbock, Texas
Tifton, Georgia	Weslaco, Texas
Urbana, Illinois	Logan, Utah
Baton Rouge, Louisiana	St. Croix, Virgin Islands
Beltsville, Maryland	Prosser, Washington
Frederick, Maryland	Pullman, Washington
St. Paul, Minnesota	Kearneysville, West Virginia
Bozeman, Montana	Madison, Wisconsin
Ithaca, New York	

Following are some examples of recent progress:

Elucidation of strains of *Verticillium dahliae* involved in epidemic of *Verticillium* wilt in pistachio - Davis, California. Characterization of

isolates of V. dahliae obtained from several pistachio orchards showed that two strains are primarily involved in the epidemic of Verticillium wilt in this crop. The strains, identified as SS-4 and T-1, cause lethal disease in trees in the field and in the greenhouse. These results indicate that screening for resistance in pistachio will require the use of both strains and that cultivars used as rootstocks for disease control must be resistant to both strains.

Confirmation of the identity of the Verticillium spp. causing wilt in alfalfa - Davis, California. Laboratory studies on the morphology of the Verticillium isolate from alfalfa confirmed the findings in recent studies by others that the fungus is V. albo-atrum, a fungus known in the northern U.S., Canada, and Europe. The occurrence of this pathogen in desert areas of the western United States suggests that this particular isolate may have some characteristics that differ from isolates that occur in other areas.

Detection of Verticillium dahliae in grapevines in California's San Joaquin Valley - Davis, California. Verticillium wilt caused by V. dahliae was found for the first time in the central San Joaquin Valley. The disease was seen in the cultivar Emerald Riesling, but was not found in adjacent plantings of Chenin blanc and Barbera. The strain of V. dahliae in grapevines in California is the mild cotton SS-4 strain. It was previously thought that environmental conditions in the central San Joaquin Valley were not favorable for the disease in grapevines. Differences in the susceptibility of grapevine cultivars appear to be a major factor determining whether the disease will occur.

Selection of Verticillium wilt-resistant olive rootstock - Davis, California. Sixty-two seedling trees of 'Oblonga' were selected with resistance to Verticillium wilt that appears to exceed the resistance of the original 'Oblonga' cultivar. Further evaluation of these resistant selections may result in a rootstock that will prevent transmission of the pathogen through grafts to susceptible commercial olive cultivars. An effective rootstock appears to be the best means of preventing heavy losses in olives to Verticillium wilt, the most important disease in this crop.

Resistance of Pistacia integerrima to Verticillium wilt - Davis, California. Pistacia integerrima was found to be resistant to Verticillium wilt. When used as a rootstock, it is an effective means of controlling Verticillium wilt in commercial cultivars of pistachio. P. integerrima appears to be effective even though a high percentage of the trees develop vascular symptoms in greenhouse tests. In six plots where P. integerrima was grafted with buds of the commercial cultivar and trees ranged between 8-10 years old, no Verticillium wilt was seen although the trees had been planted in soil from which diseased trees were removed.

Comparisons of foreign and domestic nematode populations - Salinas, California. Three domestic and eight foreign nematode populations increased by serial transfers had similar degrees of infectivity on tomato. Results suggest that plant resistance developed for a single nematode population would be effective for other geographically isolated populations. Resistance-breaking biotypes were not detected in any of the nematode populations.

Recovery of hydrid embryos from Carica papaya and C. cauliflora - Miami, Florida. The recovery of hybrid embryos from a cross of Carica papaya and Carica cauliflora is significant in that a fertile hybrid could be used as a tool to transfer papaya ringspot virus resistance to economically important papaya plants. The development of multiple embryos through tissue culture techniques is of prime importance from the point of view of being able to obtain large populations of genetically uniform plants. Polyembryony in the nucellus has an additional advantage in that bacteria associated with and difficult to eliminate from the seed coat of papaya are not present in nucellus tissue.

Incompatible responses to citrus nematodes identified - Orlando, Florida. Citrus rootstock incompatibility to Tylenchulus semipenetrans was correlated with four distinct cellular responses to infection. Failure to attract citrus nematode larvae to roots was also identified as an important facet of incompatibility. The findings of this study should guide the development of new citrus nematode-resistant rootstocks which are capable of reducing the development of resistance-breaking biotypes in the field.

Technique for removing deep uncontaminated soil cores - Byron, Georgia. In a study of the fate of DBCP in southeastern soils we have learned to remove soil samples from under treated areas without contamination from the upper (treated) levels. Soil cores are removed with tube samplers through hollow-stem augers. A device was designed and made which removes an undisturbed, uncontaminated subcore.

Nematicides applied to soybeans were of little benefit - would have benefited corn - Tifton, Georgia. Nematicides were of little benefit in a soybean-corn double cropping system where stubby-root nematode was the major nematode present and the nematicide was applied to the soybean. The nematicide could have been of more benefit if it had been applied to the corn because stubby-root nematode is only lightly pathogenic on soybeans and there were indications of up to 25 percent damage to the corn.

Resistant soybean adequate for nematode control - Tifton, Georgia. In a corn-soybean double cropping system, a nematicide applied to Cobb soybean (a variety resistant to root-knot nematode) planted after two corn hybrids susceptible to this nematode, increased yields only 2.2 bu/A. Planting this variety in double cropping systems where this nematode is present can serve to eliminate the need for a nematicide and thus provide savings of as much as \$20/A.

Ethylene dibromide is the most effective nematicide for nematode control on soybean - Tifton, Georgia. Ethylene dibromide was shown to be more effective for nematode control on soybeans than several organophosphate and carbamate nematicides. Use of ethylene dibromide can result in as much as 10 bu/A greater yield than can be obtained with the two other types of nematicides or a difference in net return of \$47.

Postplant application of nematicide to peanut effective against nematodes - Tifton, Georgia. Postplant applications of nematicides to peanuts controlled nematodes and increased yields as much as 425 lb/A or a net return of \$77/A.

This practice could be used as a "salvage operation" to save a crop when the need for a nematicide was not recognized until after the peanuts were planted.

Broad-spectrum soil fumigants applied to an intensive cropping system were not economically feasible - Tifton, Georgia. Annual applications of DD-MENCS (35 gal/A) and methyl bromide (320 lb/A) suppressed populations of soilborne fungi and nematodes to very low levels throughout the year in a turnip-field corn-southern pea cropping sequence. The mean net return (\$/A/yr) for five years was -\$363, -\$198, and +\$277 for methyl bromide, DD-MENCS, and no chemical control, respectively. Maximum pest control in this irrigated intensive cropping system was not economically feasible under current prices and production technology. Use of broad-spectrum soil fumigants greatly reduces risk to damage caused by nematodes, weeds, soilborne fungi, and insects.

Southern pea resists root-knot nematode - Tifton, Georgia. The integration of 'Worthmore' southern peas (root-knot resistant) into an irrigated turnip-field corn-southern pea cropping sequence suppressed numbers of root-knot nematodes and increased yields equal to the use of a nematicide (phenamiphos). Planting 'Worthmore' in intensive cropping sequences where the root-knot nematode (Meloidogyne incognita) is present can eliminate the need for a nematicide, reduce cost of nematode control compared with chemicals (up to \$40/A), reduce unit production, and reduce pesticide residue in the soil.

Nematicides applied through a sprinkler irrigation system controlled nematodes and increased yield of field corn and squash - Tifton, Georgia. Phenamiphos and ethoprop were applied to field corn and squash via injection into a sprinkler irrigation system and this method was compared with a conventional application of the nematicide granules spread on the soil surface and incorporated into the top 15-cm soil. Both nematicide application methods were equally effective in crop response, yield increase, and nematode control. Yield increases of corn and squash were 54 and 196 percent, respectively, from treated plots compared with untreated plots. These data will result in (a) application of selected nematicides through irrigation to optimize nematode control and increase yields 20 percent or more in multiple-cropping production systems, (b) reduced cost of nematicide application by 40 percent compared with conventional methods, and (c) increased human safety by utilizing closed pesticide application systems.

Resistance to the soybean cyst nematode - Urbana, Illinois. A germplasm release of L77-994, an MG III line with resistance to races 1, 3, and 4 of the soybean cyst nematode (SCN), was made. This was a cooperative effort by the USDA, the Illinois Agricultural Experiment Station, and the Missouri Agricultural Experiment Station. A higher yielding subline of L77-994 is expected to be released as a variety in March 1981. This line is adapted to a wide area of the Midwest and will be of great significance to the farmers who have SCN infestation.

Applications of aldicarb at reduced rates - Urbana, Illinois. Aldicarb 15G is one of the most efficacious nematicides registered for control of the soybean cyst nematode. Growers, however, are reluctant to use the recommended banded rate of 14 to 20 lb/A due to cost (aldicarb cost to the grower is approximately \$2/lb). Tests this year showed that 10 to 14 lb/A are

effective and can result in savings to the grower of \$8 to \$12/A. In-furrow applications of approximately 5 to 7 lb/A are also effective, and this can result in an additional savings to the grower and reduce chances of environmental contamination. A 24C label for in-furrow applications is being applied for by the manufacturer for the 1981 growing season.

Nematicides combined with cultural practices preserve sugarcane stubble and increase production - Baton Rouge, Louisiana. Field experiments involving use of nematicides and replanting of existing stubble, on the sides and in the center, continue to show an increase in sugarcane production and could save farmers the inconvenience and expenses of completely renovating and replanting the crop every third year. Should this practice be adopted by farmers, it would improve land use and save fallow plowing in the sugarcane crop rotation.

New host plant (sugarcane) discovered for the Columbus lance nematode - Baton Rouge, Louisiana. Sugarcane has been identified as a new host plant for the Columbus lance nematode, Hoplolaimus columbus, and its pathogenicity and parasitic relationships to sugarcane have been determined. This nematode is known as a virulent pathogen of soybeans, but has not been found previously in Louisiana nor reported before on sugarcane.

Monilinia fructicola (American brown-rot fungus) is shown as distinct from two near relatives - Beltsville, Maryland. Monilinia fructicola, M. johnsonii, and M. amelanchieris were cross-inoculated onto young shoots and firm ripe fruits of peach, apricot, plum, pear, and on two species each of Crataegus and Amelanchier. M. fructicola was the only pathogen capable of invading uninjured tissues of the four orchard crops. These experiments, and symptoms on experimentally injured peach, confirmed results of micromorphology studies that the three fungus species are distinct and that M. fructicola can be distinguished from the other two species that sometimes develop on peach.

Laterispore is a newly discovered fungus - Beltsville, Maryland. A dark-colored hyphomycete (fungus) has been found on sclerotia of Sclerotinia sclerotiorum, an important plant pathogen. The hyphomycete apparently develops only on sclerotia parasitized by Sporidesmium sclerotivorum or Teratosperma oligocladum. The fungus is distinctive in its manner of spore development and is recognized as a previously unknown genus and species, which has now been named Laterispore breviramus. Its effect on the sclerotia and interaction with Sporidesmium and Teratosperma is undetermined.

New parasite for the Colorado potato beetle - Beltsville, Maryland. Specimens of a mermithid nematode, parasite of the Colorado potato beetle, were obtained from Austria and released in a cage at the Beltsville Agricultural Research Center with some of our Colorado potato beetle larvae. The nematode parasite became established in the soil and infected the larvae of the pest insect. Its potential for use in biological control is now being evaluated. The Colorado potato beetle is one of the most important pests in the northeast region of the United States and is resistant to most insecticides. A biological control organism which can kill and suppress populations of this insect would be of great benefit to agriculture.

A new root-knot nematode species on grape in Michigan - Beltsville, Maryland. A morphological study of nematode specimens from grape (Vitis labrusca) in Michigan revealed the presence of a previously unknown species of root-knot nematode. In cooperation with two Michigan State University scientists, this remarkable species has been described and named Meloidogyne nataliei. This is a highly destructive pest on grape, causing severe damage to the roots and deterioration and eventual death of the plants. This new grape parasite is presently known only from the original infested vineyard at Mattawan, Michigan. Surveys and biological research, including host range studies, are being conducted by scientists in Michigan.

Possible biological control agent for root-knot nematodes - Beltsville, Maryland. Yields of cucumber fruits increased significantly where spores of the bacterial hyperparasite of nematodes, Bacillus penetrans, had been added to field soils infested with root-knot nematodes. In these initial trials, the bacterium reduced the level of plant injury and perpetuated itself in soils as a possible permanent antagonist of the plant nematode species.

Potential use of satellite viruses for biological control - Beltsville, Maryland. In tobacco plants infected with cucumber mosaic virus in the presence of cucumber mosaic virus-associated RNA 5 (CARNA 5), large quantities of double-stranded CARNA 5 are accumulated in symptomless leaf tissue where biochemically synthesis of CARNA 5 out competes synthesis of viral RNA. Identification of this type of "molecular parasitism" is significant because it suggests experimental approaches for biological control of virus disease.

Cloned DNA complementary to potato spindle tuber viroid now available as a molecular probe - Beltsville, Maryland. DNA complementary to potato spindle tuber viroid (PSTV) has been cloned and can be produced in quantity and labeled with  $^{32}\text{p}$  for use as a molecular probe. Availability of such a probe should significantly simplify our efforts to study the mechanism of reproduction of viroids and will be extremely useful in the screening of "seed potatoes" for the presence of PSTV.

Spiroplasmal etiology of horseradish brittleroot disease - Beltsville, Maryland. In collaboration with the University of Illinois, methods developed for the culturing and characterization of spiroplasmas have been used to determine the spiroplasma etiology of brittleroot disease of horseradish. This is a significant application of basic research to a serious disease problem. The identification of the causal agent should simplify efforts to control the disease.

Freeze-etching technique further simplified - Beltsville, Maryland. A new specimen cap and new specimen holders have been designed for freeze-etching. The new design eliminates the need for hinged complementary specimen holders. The hinges have been a problem because if liquid from the sample finds its way into the hinge and is frozen, the hinge breaks and destroys the \$20 holder. The new holders should never need to be replaced.

New biotypes of a biocontrol agent have been developed - Beltsville, Maryland. Three new groups of genetic biotypes from three wild strains of Trichoderma

harzianum, a potential biocontrol agent for soilborne diseases, have been induced by UV light irradiation and selection. Some of the new variants possess superior abilities to suppress stem rot, root rot, damping-off, and seed decay caused by soilborne plant pathogens. In addition the new biotypes tolerate some fungicides, a characteristic that makes them good candidates to be used in IPM systems together with small amounts of fungicides. This accomplishment introduces new concepts to the biocontrol of plant pathogens and suggests that superior strains can be developed, not only of Trichoderma, but also of many other antagonists. This accomplishment will stimulate new areas of research for improving biocontrol by altering the genetic code of control agents.

New mycoparasite provides continued biological control of lettuce drop - Beltsville, Maryland. Application of the beneficial mycoparasite Sporidesmium to field plots in May 1978 caused a 94 percent reduction in the population of the lettuce drop fungus, Sclerotinia minor, by December 1978. The population of S. minor remained low, thereafter, through September 1980 as a result of continued destructive action of Sporidesmium on the plant pathogen in the soil. Biological control of 65 and 75 percent resulted from the highest treatment rate on two successive lettuce crops in 1980. These findings demonstrate that mycoparasitism can be a useful method to control soilborne diseases of plants in the field and may have long term, beneficial, residual effects.

A practical system for disease forecasting developed - Beltsville, Maryland. Completion of 3 years of research in onion production fields in New Jersey has shown that a practical white rot forecasting system is possible and could be implemented at any time. This research has shown that there is a good correlation between the population of the plant pathogen in the soil at the time of planting and disease severity at harvest. With methods developed in this project, a disease forecasting system could be implemented to advise growers whether to plant fall-planted onions in a particular field. When such a forecasting system is put into effect, fields normally planted to crops in the onion family could be left unplanted to prevent losses or, if needed for planting, could be treated by chemical or biological means at the proper time.

Tillage practices reduce diseases caused by fungi - Beltsville, Maryland. For the second continuous year, damping-off and blight diseases of beans, caused by soil fungi, were reduced by plowing the field to a depth of 8-10 inches rather than by disking to 2-3 inches before planting. Bean plant stand as well as yield can be increased twofold by this procedure. Use of antagonistic biocontrol agents or small amounts of seed-treatment fungicides, or both, contributed to the increase. This combination of cultural, chemical, and biological control practices contributes to solving problems for which no other accepted control measures are known.

Improved soilborne disease control at reduced cost - Beltsville, Maryland. Application of metham (Vapam<sup>R</sup>) at 1/4-1/3 the label rate through sprinkler irrigation 2-3 weeks before planting lettuce provided 89 percent control of Sclerotinia lettuce drop in a production field. This method and rate of application of Vapam<sup>R</sup> provided improved disease control and cost \$125/acre

less than the standard method of control for this disease. When these results are confirmed and put into commercial practice, lettuce production should increase with less production costs to the grower.

How an antagonist is grown determines how well it controls disease - Beltsville, Maryland. Laboratory studies have demonstrated that the ability of a biocontrol fungus to inhibit a pathogenic fungus depends on how, and on what, the biocontrol fungus is grown. Stilbella, a new biocontrol fungus, grows well on oats and wheat bran, but best biocontrol activity occurs when it is grown on cornmeal, a material on which there is not abundant growth. Similar results occurred with the antagonist Trichoderma. These results demonstrate the importance of culturing potential biocontrol agents on the best medium and emphasize the point that biocontrol can be enhanced by existing antagonists if we can understand the ecological and nutritional factors that favor their establishment in soil.

Sludge compost controls important soilborne diseases - Beltsville, Maryland. Composted municipal sludge added to soil at the rate of 10 percent significantly suppressed Sclerotinia minor disease of lettuce and Rhizoctonia solani rot of beans, peas, and cotton in Beltsville field trials. The effect of compost as a source of plant nutrients lasted through three successive crop plantings. The use of compost for disease control may have significant importance, especially in its application to minimize disease losses in small farm operations.

Minor use pesticide research will result in fungicide label amendment - Beltsville, Maryland. Field tests for 2 consecutive years showed that the present label rate of chlorothalonil (Bravo<sup>R</sup>), 4-1/4 pt/A, is not adequate to control cucumber fruit rot ("belly rot") caused by Rhizoctonia solani. A single heavy application at 6 qt/A resulted in significant disease control without increasing residues in fruit beyond the present legal tolerance. This cleared the way for amending the present label to include the heavy use. This will provide a temporary method of disease control until other methods become established.

Maize streak virus transmission by South American Cicadulina - Frederick, Maryland. Natural transmission of maize streak virus (MSV) is restricted to some five species of African leafhoppers in the genus Cicadulina. Injection-testing of 13 species of North American leafhoppers, some closely related to Cicadulina, revealed no transmission by members of this group. The injection of MSV into a South American species of Cicadulina (C. pastusae) did, however, result in a low level of transmission. This transmission, although low, suggests a fairly recent geographical separation of the South American and African Cicadulina, and is the first physiological evidence of a relationship that until now was based solely on taxonomic characters.

Evidence for separate origins of maize and maize streak virus (MSV) - Frederick, Maryland. Sources of tolerance or resistance to maize streak virus (MSV) were found in five annual teosinte collections originating in Guatemala. The remaining 40 annual teosinte collections from Mexico, Guatemala, and the United States were highly susceptible. The perennial teosintes were immune. Two Tripsacum andersonii entries and eight nonspecific Tripsacum entries

from the World Tripsacum Collection were susceptible to MSV. The remaining six species and 40 nonspecific entries were immune. The patterns of susceptibility and immunity in these New World ancestors of Zea mays, the almost complete susceptibility in cultivated maize, the wild grass host range, and the nature of the causal virus and vectors provide evidence for separate origins of maize and MSV.

The host cell nucleus collapses in the hypersensitive resistant reaction in plant disease - St. Paul, Minnesota. The hypersensitive death of resistant plant cells was found to be preceded by abrupt collapse of the nucleus within each resistant cell. Along with a halt in cytoplasmic streaming, the nuclear collapse indicates that toxic substances cause damage throughout the cell. The results bring us one step closer to an understanding of the processes leading to an important type of plant disease resistance.

Additional virulence genes do not affect pathogen fitness per se in wheat stem rust - St. Paul, Minnesota. Cultures with increasing numbers of virulence loci were found in predicted numbers in the U.S. wheat stem rust population, indicating no detrimental effect of increasing number of recessive loci. Upon examination of the 16 virulence loci, examined in all their paired combinations, none deviated strongly from expected mean frequencies based on products of individual locus frequencies, and provided no evidence for strong positive or negative fitness effects associated with individual genes. Thus, there seems to be no evidence that complex races would be more unfit than simple races. Addition of genes indiscriminately for resistance has no intrinsic value indicating that the costly effort to maintain genes that provide no specific resistance is of little benefit.

Clustering of virulence genes in wheat stem rust suggests new strategy for long-lasting rust resistance - St. Paul, Minnesota. The distribution of virulence for the 16 host genes studied in the Great Plains stem rust population was characterized by clusters of phenotypes. These clusters differed from one another by four to 10 virulence genes whereas the rusts within clusters differed by only one to two loci. It should be possible to provide long lasting resistance by breeding cultivars with combinations of resistance genes midway between these clusters of pathogen virulence.

Interspecific oat hybrids developed that are immune to prevalent races of oat crown rust and stem rust - St. Paul, Minnesota. Highly effective resistances involving relatively few genes were found in Avena longiglumis and A. magna. These resistances have not been used previously in oat breeding.

Wheat stem rust fungus shown to be functionally and asexually reproducing in the Great Plains - St. Paul, Minnesota. Distinct differences were found in virulence patterns in sexually and asexually reproducing populations of wheat stem rust. The evidence indicates that the Great Plains population of stem rust changes only by mutation; and if sexual and parasexual individuals are produced, they are eliminated from the population before we can detect them. This evidence means that the pathogen will remain relatively stable. Thus, an addition of a gene for virulence by mutation in a commonly found, well adapted race group would be considered more hazardous than the addition of the same virulence in a less frequently occurring race group.

An explanation for the durable resistance of Chris spring wheat to stem rust - St. Paul, Minnesota. Chris wheat was found to have additive recessive genes for low receptivity to infection by the virulent stem rust race 15B6. Race 15B6 was moderately virulent on seedlings and produced susceptible pustules on adult plants of Chris in greenhouse tests. A cross of Chris with highly receptive Baart wheat yielded progeny that had ultralow receptivity in a 1980 field test of  $F_2$  families inoculated with a culture of race 15B6. This multigenic resistance resembles that found previously in progenies from Thatcher/Lee, both of which are present in the pedigree of Chris. The continued resistance of Chris wheat after the appearance of the potentially hazardous race 15B6 apparently results from this additive multigenic resistance.

Managing the golden nematode reduces hazard of spread - Ithaca, New York. Management systems utilizing nematode resistance, non-hosts, and minimal nematicide usage have been developed that manage golden nematode densities where spread is unlikely to occur. This advancement is important to the Golden Nematode Quarantine and Regulatory Program. When such systems are utilized on golden nematode-infested land, nematode densities will decrease and spread will be limited. When used on noninfested land, such systems will prevent establishment of the golden nematode if spread does occur.

Resistance found to a new species of root-knot nematodes attacking potatoes - Ithaca, New York. A potato clone of Solanum tuberosum subsp. andigena that was previously found to be resistant to Meloidogyne hapla is also resistant to M. chitwoodi, a new species of root-knot nematode that causes serious damage to potatoes in large areas of the Pacific Northwest. This clone will be a valuable source of resistance in breeding for resistance to this important pest of potatoes.

Phytophthora root rot protection by mycorrhizal fungi and bacteria - Corvallis, Oregon. Selected mycorrhizal fungi and rhizosphere bacteria have shown good potential in greenhouse studies for suppressing infections and symptom development by the widespread root pathogen, Phytophthora cinnamomi. The fungus causes serious losses in many nurseries as well as landscape situations. Studies have demonstrated the importance of inoculation and establishment of the mycorrhizal fungi and bacteria on the host before the pathogen is introduced. In addition, some of the protectant organisms appear to enhance plant growth before exposure to the pathogen.

A repeatable protocol for regenerating whole plants from eggplant callus was developed - Charleston, South Carolina. Cultural and environmental conditions were identified for obtaining callus from isolated protoplasts. Whole plants were regenerated from protoplast-derived callus. This is a significant step toward development of an eggplant hybrid with root-knot nematode resistance through somatic hybridization.

Improved rearing procedures developed for a mermithid nematode - Charleston, South Carolina. In vitro culture of the nematode Filipjevimermis leipsandra, a parasite of the corn rootworm, was accomplished for the first time and the full life cycle of a mermithid nematode was obtained in the absence of a host. This may give us the capacity to rear enormous numbers of nematodes inexpensively for the biocontrol of the corn rootworm.

New soybean variety released - Jackson, Tennessee. The new soybean variety Nathan was released to Illinois, Kentucky, Missouri, and Tennessee. This variety, developed by Dr. E. E. Hartwig and Mr. J. M. Epps, has resistance to Races 1, 3, and 4 of the soybean cyst nematode and resistance to root-knot nematode. The variety is approximately 10 days earlier than the current race 4-resistant variety Bedford, thus making it more adaptable to southern Illinois, Missouri, and Kentucky than Bedford. The variety should yield at least 5 bushels per acre more than susceptible varieties when grown in fields infested with race 4 of the soybean cyst nematode.

Nature of nematode resistance in cotton - College Station, Texas. A major mechanism of resistance of cotton to the root-knot nematode has been elucidated. The mechanism is predicated on the ability of resistant cottons to respond to nematode infection by producing terpenoid aldehydes at the feeding site of the nematode. Terpenoids so produced inhibit the development and reproduction of the nematode and consequently reduce subsequent field populations of the parasite. This knowledge can be useful to plant breeders attempting to develop genetically resistant plants, and forms the basis for further studies on the nature of parasitism and host-plant resistance.

New knowledge on the biology of the nematode *Nothanguina phyllobia* - Lubbock, Texas. New knowledge was generated relative to oxygen, temperature, pH, and osmolality in the life process of the nematode. These findings are essential for the development of an artificial rearing procedure for the nematode for biocontrol purposes.

Soil temperature affects root-knot nematodes on potatoes - Logan, Utah. Soil temperature, as it affects nematode reproduction, is the limiting factor in the host/pasasite relationship of root-knot nematodes on potato; and a soil fumigant treatment is necessary before each potato planting.

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WEED CONTROL TECHNOLOGY FOR PROTECTING CROPS,  
GRAZING LANDS, AQUATIC SITES, AND NONCROPLAND

This multidisciplinary national research program emphasizes the development of principles of weed science and safe and efficient practices of weed control that can be integrated with other production and protection technology into weed management systems for improving crop and livestock production. This research is essential to the development of high-yielding food, feed, and fiber agroecosystems that will maintain the Nation's food supply and improve the quality of the environment. It supports the missions and goals of ARS, SE and the Department. The intramural research program is organized into 98 projects at 36 domestic locations and is conducted by 73 ARS scientists in cooperation with several Federal agencies, State agricultural experiment stations (SAES), private universities and research institutes, and industrial research organizations. This NRP also supports 39 cooperative extramural research projects by 26 SAES scientists in 25 states and 7 PL480 projects by 10 foreign scientists in four foreign countries. In 1980, progress was reported in more than 150 scientific publications.

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Technological Objective 1: New and improved fundamental knowledge of the biology of weeds for development of safe, new principles and mechanisms of their control by biological, chemical, cultural, ecological, physical, and integrated methods that will avoid or minimize hazards to nontarget organisms and to other components of the environment.

Research Locations:

Tucson, Arizona	Columbia, Missouri
Stuttgart, Arkansas	Ithaca, New York
Albany, California	Raleigh, North Carolina
Tifton, Georgia	Fargo, North Dakota
Urbana, Illinois	College Station, Texas
Lafayette, Indiana	Temple, Texas
Beltsville, Maryland	Logan, Utah
Frederick, Maryland	Prosser, Washington
St. Paul, Minnesota	Pullman, Washington
Stoneville, Mississippi	Kearneysville, West Virginia

Examples of Recent Progress:

A rapid and effective method of screening herbarium plant specimens for aliphatic nitro compounds toxic to animals was developed - Logan, Utah. Foreign nitro-bearing Astragalus were identified and classified into taxonomic sections.

Identification of nitro-bearing plant species of Astragalus could be made before the plants were introduced as potential forage plants and could eliminate the time, expense, and scientific effort of needlessly collecting and developing plant species that are unsuitable for grazing. The nitro-bearing species of Astragalus could be intercepted before they are released as forage plants on western range, and subsequent animal losses from poisoning and recurring control costs could be prevented.

Growth regulator delays weed seed shedding - Frederick, Maryland. Foliar applications of a commercial gibberellin preparation delayed the shedding of wild oat seed. This research conclusively demonstrates a physiological effect of a growth regulator that could potentially be useful in controlling wild oat by preventing the premature shedding of weed seed that then become a reservoir for reinfestation of small grain fields.

Sunflower reduces weed populations - Frederick, Maryland. Some commercial sunflower varieties reduce the density of weed populations more than do wild sunflowers. This research strongly suggests that further breeding could enhance the weed-suppressing capabilities of this crop and reduce the need for other means of weed control.

Several agricultural chemicals increased while others decreased, the contents of all major alkaloids (morphine) in latex isolated from the poppy, Papaver somniferum - Beltsville, Maryland. Alkaloid contents were increased by glyphosate, ethephon, glycosine, and pyridoxyl 5-phosphate and were decreased by nuarimol, amitrole, and fenarimol. These results indicate the need to understand the enzymatic regulation of alkaloid biosynthesis, and the metabolic generation of morphine and how this may be manipulated both for the control of production of illicit narcotics and enhancement of legitimate production of useful narcotics such as thebaine, codeine, and morphine.

New chemicals control narcotic plants - Beltsville, Maryland. Eleven of sixteen chemicals included in the 1979 field evaluation studies were selected for evaluation of their potential as post-emergence treatments for controlling marijuana and opium poppy. Marijuana and opium poppy grown in the greenhouse were successfully controlled by five and seven new chemicals respectively. Several candidate herbicides were selective in action. Consideration of the use of these chemicals for the control of narcotic plants is, in part, contingent on their development by industry.

Effect of herbicides on foliar amino acid content of five plant species - College Station, Texas. Changes in amino acid concentrations in forage may have some practical applications in livestock and wildlife production. In western ragweed, amino acid concentration was increased by atrazine and decreased by dalapon, dicamba, 2-4-D, glyphosate and triclopyr. In roundseed dicanthelium, 27 days after treatment, amino acid concentration was increased by atrazine, bromacil, dicamba, 2-4-D, tebuthiuron, 2,4,5-T and triclopyr. In brush (yaupon, honey mesquite, Macartney rose), the response was variable and ranged from slightly increased to decreased concentrations for most herbicides studied.

Plant cell cultures useful in wild oat research - Fargo, North Dakota. Wild oats cause losses of more than \$300 million in small grains and other crops each year. Plant cell cultures are a valuable research tool in the fight against wild oat. The differential metabolism of a new selective herbicide,

diclofop-methyl, was examined in aseptically-grown cell-suspension cultures of wild oat, cultivated oat and wheat. Herbicide metabolites were qualitatively the same as those reported in intact plants. Relative rates of metabolism and detoxication were correlated with herbicide tolerance. Metabolism rates were highest in tolerant wheat, intermediate in cultivated oat, and least in susceptible wild oat. Results were consistent with observations of field tolerance and demonstrated the effectiveness of plant cell cultures as a model system to determine the selective action and fate of wild oat herbicides in small grains.

Chemicals identified in Russian Knapweed that are toxic to livestock - Albany, California. Several sesquiterpene lactones (some of which are known to be cytotoxic) were isolated and identified from Russian Knapweed and may be associated with the observed detrimental effects the plant has on grazing animals viz., the disease Equine Nigropallidal Encephalomalacia (ENE).

Weeds persist after six years of weed-free maintenance - Tifton, Georgia. Low populations of Texas panicum, cocklebur, Fla. beggarweed, sicklepod, and morningglories were still present after six years of weed-free maintenance that included use of soil fumigation, maximum herbicide usage, and handweeding in intensive cropping rotations that produced 15 to 18 crops on the same land area. These data indicate that weed control programs must be maintained for more than six years to reduce drastically the levels of infestation and competition.

A plant pathogen shows potential as an agent for biological control of spurred anoda - Stoneville, Mississippi. The fungus Alternaria macrospora Zimm. was evaluated as a biological herbicide for controlling spurred anoda in cotton. A method for large-scale spore production was adapted for production of spores of other fungi. Spores of the pathogen were applied as a foliar spray. Also, for the first time the feasibility was demonstrated for utilizing a biological herbicide in preemergence and postemergence applications of granular formulations. Foliar application of a spore suspension reduced the number of spurred anoda plants in the field by 75% after six weeks. Preemergence or postemergence applications in small field plots resulted in essentially 100% infection of spurred anoda seedlings.

Potential for Spread of the Exotic Noxious Weed, Witchweed, in the United States - Stoneville, Mississippi. Witchweed (Striga lutea = S. asiatica) is a parasitic plant that attacks crops in the grass family, including corn, sorghum, and sugarcane. In the US witchweed is found only in a 28-County area in the Coastal Plain of North and South Carolina. In the controlled-environment phytotron, witchweed parasitized corn and sorghum root systems in sandy loam soil at temperatures ranging from 26/17 to 32/26 C, and parasites emerged from the soil and flowered at temperatures ranging from 26/20 to 32/26 C. During the growing season, therefore, soil and air temperatures are not low enough to prevent the spread of witchweed into the major corn- and sorghum-producing areas of the United States. In these areas however, the cooler temperatures during the early season should limit the development of the parasites and reduce their impact on potential host plants.

Morningglory and nightshade produce abundant seed throughout the growing season - Shafter, California. March plantings of morningglory and nightshade produced viable seed within 9 to 12 weeks, while April through September plantings produced viable seed within 6 to 9 weeks after planting. Twelve weeks after

planting, seed production of morningglory ranged from a low of 8 seed/plant for March plantings to a high of 6500 seed/plant for July plantings. Seed production of nightshade ranged from a low of 600 seed/plant for September plantings to a high of 50,000 seed/plant for May plantings. Several weed parameters studied (vegetative growth, flowering, seed production and germination) provide information that is useful in planning control measures for these weeds.

Develops procedure for rapidly testing whole plants for triazine resistance - Urbana, Illinois. With commercially available, and portable equipment, a simple procedure was developed for rapidly testing whole plant tissues for triazine resistance. This procedure is valuable in studies on triazine resistance and has been adopted by a number of laboratories, thus improving the efficiency of their work.

Technological Objective 2: New and improved weed control technology for use in field crops that will increase efficiency in food, feed, and fiber production, reduce losses in yield and quality, and reduce the cost of control.

#### Research Locations:

Stuttgart, Arkansas	Stoneville, Mississippi
Shafter, California	Columbia, Missouri
Fort Collins, Colorado	Lincoln, Nebraska
Tifton, Georgia	Fargo, North Dakota
Urbana, Illinois	Corvallis, Oregon
Lafayette, Indiana	Prosser, Washington
Houma, Louisiana	Pullman, Washington
St. Paul, Minnesota	

#### Examples of Recent Progress:

Integrated Weed Management System (IWMS) prevents 94% loss in alfalfa seed yield due to weed competition - Prosser, Washington. Alfalfa planted in the spring in rows for seed production yielded 760 lb of high quality seed per acre when kept completely free of weeds. Even though the inter-row areas were kept weed free by tillage, a mixed population of annual weeds left uncontrolled within the alfalfa rows reduced seed yield to 44 lb per acre. An economical IWMS based on profluralin applied to the soil before seeding, 2,4-DB applied postemergence, trifluralin applied broadcast when the alfalfa was 8 inches tall and incorporated with a power-driven tine-tooth harrow, inter-row tillage, and a nominal input of hand labor controlled weeds, completely prevented yield loss from weed competition, and allowed production of excellent yields (760 lb per acre) of high quality alfalfa seed during the year of establishment.

Interactions of tillage, fertilizer, and herbicide on wild oat germination, growth, and control - Pullman, Washington. Germination of wild oat seed was enhanced by the presence of NO<sub>3</sub> and seed germinated at a higher temperature after it has been stored for a year than when freshly harvested. Wheat responded to soil applications of N, especially NH<sub>4</sub>-N, to a greater extent than wild oat. High rates of N reduced the effectiveness of difenzoquat applied for

wild oat control which may explain in part the lack of consistency when this herbicide is used for post-emergence wild oat control.

Reduced tillage crop systems may increase jointed goatgrass germination and seedling emergence - Pullman, Washington. Jointed goatgrass seeds germinate best at 15 or 20 C but did also germinate at temperatures ranging from 10 to 35 C. Seedlings did not emerge from greater than 5-cm depths. This may explain the increase in jointed goatgrass infestations in reduced tillage crop production systems.

Paraquat may be useful for control of wild garlic - Columbia, Missouri.

Paraquat applied to wild garlic in November or early December for 4 years controlled wild garlic in a field continually cropped to soybeans. At one lb per acre paraquat killed all emerged wild garlic plants. Annual applications were necessary to kill plants that emerged from hard-shell bulbs that remain dormant for 4 or 5 years.

Atrazine shows promise for controlling wild garlic - Columbia, Missouri. A wild garlic infested soil treated with 5 lb per acre of atrazine and soil incorporated by disking for 3 years in October remained free of wild garlic in the fall of the fourth year. These results indicate that it may be possible to eradicate wild garlic in a cropping system in which atrazine could be used annually for 4 or 5 years.

Center pivot irrigation systems effectively and economically apply herbicides - Tifton, Georgia. The following herbicides were applied on the crops indicated through center pivot irrigation systems under grower conditions: corn - butylate, metolachlor, alachlor with atrazine and cyanazine; peanuts - alachlor, benefin, and benefin with vernolate; soybeans - pendimethalin, oryzalin, metolachlor, and alachlor with metribuzin. These results have led to 10 new or expanded registrations for use of the above herbicides.

New technique controls troublesome weeds - Tifton, Georgia. Two very troublesome weeds in peanuts, Florida beggarweed and sicklepod, were suppressed or killed by the nonselective herbicide, glyphosate, delivered through nonmechanical rope wick devices. Further refinement of this technique should enable farmers to control those weeds and thus increase their net profits by \$5 to \$30 per acre.

New preemergence treatment controls weeds in sweet sorghum grown on sandy soil - Tifton, Georgia. A mixture of propazine and methlachlor applied as a preemergence treatment following pretreatment of the crop seed with a material that reduces the risk of herbicide injury to crops provided excellent selective broadspectrum weed control for sweet sorghum without crop injury. No preemergence herbicide treatment is registered for sweet sorghum on sandy soils. Sweet sorghum has been identified as a potential crop for ethanol production. These results will contribute to improved sweet sorghum production for use as a food and as a source of energy.

Conservation tillage increases pest pressure and reduces nutrient uptake - Tifton - Georgia. The occurrence of weeds, volunteer crops, soil-borne pathogens, and insects was always greater where conservation tillage (rip-plant) was used in multiple-cropping sequences when compared to clean seedbed

preparation (deep-turning). In addition, nutrient uptake by some crops such as field corn was reduced by 10% where conservation tillage rather than deep-turn tillage was practiced. Insecticides and fungicides applied through a center pivot irrigation system controlled diseases and insects, but herbicides did not control weedy volunteer crops. These data show that seedbed tillage practices must be included as part of pest management for multiple cropping rotations on some soil types in some regional agroecosystems.

Bermudagrass biotype show differential susceptibility to herbicides -

Stoneville, Mississippi. Bermudagrass biotypes collected in nine Mississippi Delta counties vary widely in their susceptibility to several postemergence herbicides. Biotype susceptibility ranged from less than 20% to greater than 90% eight weeks after application for glyphosate at 1 to 2 kg per ha, sethoxydim at 0.5 to 1 kg per ha, and Ro 13-8895 at 0.5 to 1 kg per ha. Dalapon at 2 and 4 kg per ha and difenopropotil at 0.5 to 1 kg per ha did not provide adequate control, but biotypic variability was observed. Bermudagrass biotypic variability must be considered and herbicide rates sufficient for adequate control must be recommended to producers.

New herbicide systems control johnsongrass in soybeans - Stoneville, Mississippi. Glyphosate, applied for two consecutive years by rope wick applicator in combination with preplanting soil-incorporated trifluralin, controlled rhizome johnsongrass in soybeans, and resulted in yield increases each year in comparison to the untreated control. In the third year no herbicides were used, yet the population of johnsongrass was only 3% of that in the control plot. In the plot treated with glyphosate alone, population of johnsongrass was 15% of that in the control but yield of soybeans was highest. In the third year, soybean yield in the plot treated with wick-applied glyphosate was 3160 kg, compared to half that amount during the first year of treatment.

Rope wick applicators reduce weed control costs - Stoneville, Mississippi. A rope wick applicator was invented that contains a fully automatic, non-mechanical recovery system. The recovery system completely eliminated waste of herbicide solution due to dripping, thus reducing pollution of the environment and injury to crop plants sometimes observed with conventional wick applicators. Preliminary data indicate that by use of this applicator, a farmer using 6-row equipment could save as much as \$135.00 per day in value of herbicide recovered.

Predicting weed losses in sugarbeets - Ft. Collins, Colorado. Reduction in root yield of sugarbeets caused by low densities of a mixed population of common lambsquarters, kochia, and redroot pigweed can be predicted. Yields of sugarbeet roots decreased when three to six of these broadleaf weeds per 100 feet of row competed with sugarbeets all season. Sugarbeets are currently thinned with electronic machines. Since these machines cannot distinguish between weed and sugarbeet plants, weeds remain in the row after thinning. Growers therefore need to know whether removal of the remaining weeds would be economical. Thus, the predictive equation and the competitive threshold levels of those three broadleaf weeds would help growers to determine whether removal of the weeds by hand labor or other methods would be cost effective.

Preplant soil-incorporated herbicide combination performs well in narrow-row cotton - Shafter, California. Over two seasons cotton grown in 51-cm rows

out-yielded cotton grown in 102-cm rows by 241% where preplant soil-incorporated combinations of trifluralin (0.7 kg per ha) and prometryn (2 kg per ha) were used. A similar combination with fluometuron (1.7 kg per ha) showed a similar yield advantage for 51-cm rows, but fluometuron compared to prometryn reduced cotton yield. No significant yield effect for row spacing was shown where only tillage was used for weed control.

Two methods control volunteer corn - St. Paul, Minnesota. Volunteer corn can often be a serious weed in soybeans. In a two-year study at three locations, one clump of corn in every 8 feet of row reduced soybean yields an average of 31%. An early overtop spray of diclofop or later applications of glyphosate applied by rope wick to corn overtopping soybeans gave effective control. Yields of soybeans were higher with early diclofop sprays than with later glyphosate applications because volunteer corn competition had already reduced yields before glyphosate could be applied. For heavy infestations, an early overtop spray with diclofop would be preferable to prevent yield loss from competition; but, for light infestations, glyphosate applied selectively to the corn overtopping the soybeans would be preferable because it would be cheaper.

Black nightshade succumbs to fluridone - Shafter, California. Three year's research showed that low rates (0.1 to 0.3 kg per ha) of preplant, soil incorporated fluridone provided 90% or more season-long control of black nightshade. When combined with 0.6 kg per ha of trifluralin, those rates of fluridone also provided excellent control of annual grasses and pigweed.

New herbicide programs improve weed control in rice - Stuttgart, Arkansas. Several new herbicide treatments improve weed control and safety to rice, reduce the amount of herbicides required for weed control, and decrease the number of applications to reduce energy requirement for rice production. Tank mixtures of either butachlor, thiobencarb, or pendimethalin plus propanil applied early postemergence control emerged weeds and those that germinate for 4 to 6 weeks after application. Because butachlor, thiobencarb and pendimethalin give residual weed control, they can save a total of three applications of herbicides including one application each of propanil, molinate, or phenoxy herbicides. In 1981, these new herbicide treatments should increase grain yield and quality of rice by 10% and reduce by one or two the number of herbicide applications on 800,000 acres of rice in the South. The increased grain yield and reduced application cost are valued at an estimated \$40 million annually to the rice industry in the South.

Relatively short nutsedge-free periods in cotton prove helpful in reducing yellow nutsedge competition and preventing buildup of tubers - Shafter, California. When cotton plots were maintained free of nutsedge for 0, 2, 4, 6, 8 and 12 weeks after cotton emergence, plots hand-weeded for only 2 weeks yielded 90-95% as much cotton as plots handweeded for 8 weeks. Plots which received only cultivation yielded only 80% as much cotton. Furthermore, tuber populations in the fall did not exceed those recorded in the spring. Yields were similar for plots hoed for 6 to 12 weeks, indicating that a 6-week weed-free period was adequate to prevent yield reductions. Six to 12 weeks of hoeing also reduced the initial populations of tubers by 70 to 90%.

Weed control field history requirements in the production of certified turf-type perennial ryegrass varieties - Corvallis, Oregon. Weed-control practices

developed from 1976 to 1979, showed that existing stands of turf-type perennial ryegrass could be destroyed and reestablished to different varieties without genetic contamination. This resulted in a change of field history requirements for certification during 1980. Because of improved weed-control technology, time lapse was reduced from 5 to 2 years when changing from one variety to another. Because most perennial ryegrass varieties are raised under 4-year contracts and because many varieties are replaced by new varieties after a short period of time, the reduced time lapse when changing varieties results in a significant economic benefit to perennial ryegrass seed producers.

**Technological Objective 3:** New and improved weed control technology for use in horticultural crops that will increase production efficiency, reduce losses in yield and quality, and the cost of control.

**Research Locations:**

Tifton, Georgia	Charleston, South Carolina
Beltsville, Maryland	Weslaco, Texas
Frederick, Maryland	Prosser, Washington
New Brunswick, New Jersey	Kearneysville, West Virginia

**Examples of Recent Progress:**

New chemicals control weeds in field-grown woody nursery stock - Frederick, Maryland. Metolachlor and metolachlor-simazine combinations are now registered for use as herbicides by horticulturists in field-grown woody nursery stock. This will allow a significant reduction in mechanical labor costs for the nursery industry.

Narrow rows aid in controlling weeds and increase yield of snap beans - Beltsville, Maryland. Snap beans grown in 6- to 18-inch rows suppressed weed growth and increased yield compared to snap beans grown in conventional 36-inch rows. More rapid and complete snap bean leaf canopy development in narrow rows explains the improved weed control and higher yields. Narrow-row snap bean production is being practiced by an increasing number of growers and this research establishes that narrow rows contribute toward weed control as well as higher yield in integrated weed control programs.

Perennial grass that suppresses weeds and prevents spread of aphids in orchards is important factor in IPM program - Prosser, Washington. 'Derby' perennial ryegrass became established on orchard floors better than five other grasses and suppressed the growth of weeds effectively. The control of broadleaf weeds in peach orchards is a key factor in the IPM program to prevent the increase and spread of viruliferous green peach aphids. A management system of herbicides applied in a 2-meter strip under the trees and ryegrass alleyways between tree rows eliminated up to 95% of the broadleaf weeds in the orchard.

Charcoal protects some crops against herbicide injury - Tifton, Georgia. Terbacil was applied to the soil surface after a charcoal slurry had been sprayed over the planted seed of cucumber, squash, cantaloup and three varieties of watermelon. Charcoal protected watermelon and cantaloup but did not protect squash and cucumber from terbacil injury. This practice shows promise on

watermelon and cantaloup treated with terbacil and direct-seeded tomatoes treated with metribuzin. This application could net a watermelon grower \$150 per acre in increased yield, and weed control should also enhance harvesting efficiency.

Progress in developing aerial survey technology for weed populations - Weslaco, Texas. Ground Level (20 ft) photography in the field with conventional color (CC) film and color IR (CIR) film showed that with CIR film ragweed was more easily discriminated from carrots; johnsongrass from onions; and annual sowthistle from cabbage. With CIR film horseweed was more easily discriminated from London rocket, which was easily discriminated from lettuce; conversely, johnsongrass in cabbage was more easily seen with CC film. Palmer amaranth was poorly discriminated from cantaloup with CIR film. Taller, more mature common sunflower appeared dark red in color with CIR film. At 50 ft elevations climbing milkweed was more easily seen in citrus canopies with CIR than with CC film. Accuracy in the detection of the vine in grapefruit was 74% with CIR film with aerial (1000 ft) photography. These studies might lead to practical aerial surveys of certain weed populations in crops.

A simple weed-wiping device that can be used in controlling scattered weed stands - Kearneysville, West Virginia. A simple weed-wiping device was developed that can be used for spot-treating scattered weed stands. It consists of a hockey stick that is fitted with a self-feeding herbicide reservoir that is carried on a backpack. The blade of the hockey stick is enclosed in sponge that is covered with a protective cloth. A trigger from a handsprayer controls the flow of the herbicide. The wiper is a gravity-fed system without pressurization. Many uses are being found for this wiper including controlling weeds in cranberry bogs that are taller than cranberries, perennial weeds in orchards that are not controlled with a standard weed control program, and weeds beneath blueberry bushes. By adding a shield over the top of the blade, weeds beneath ornamental plantings can safely be controlled. This technique offers selectivity and safety to both the operator and the environment.

Technological Objective 4: New and improved weed control technology for use in forage crops, pastures, rangelands, and turf that will increase efficiency of food and feed production, improve aesthetic values, reduce losses in yield and quality, and reduce the cost of control.

#### Research Locations:

Flagstaff, Arizona	Reno, Nevada
Tucson, Arizona	Ithaca, New York
Tifton, Georgia	Corvallis, Oregon
Beltsville, Maryland	College Station, Texas
Columbia, Missouri	Temple, Texas
Lincoln, Nebraska	Logan, Utah

#### Examples of Recent Progress:

Herbicides plus nitrogen give effective weed control in turf - Beltsville, Maryland. The three more effective preemergence herbicides reduced crabgrass more than 90 percent in turf regardless of rate of nitrogen application in the fertilizer-herbicide interaction study underway since 1971. The high nitrogen rate alone gave 75% control. For the less effective herbicides, higher rates of nitrogen resulted in satisfactory crabgrass control but low rates of nitrogen resulted in marginal to unsatisfactory control. High rates of nitrogen reduced stands of volunteer dandelion plants by 81% compared to the low nitrogen rate.

Crops are more tolerant to spray drift of new rangeland herbicides than to 2,4,5-T - College Station, Texas. Spray drift to cropland from treating adjacent grazing lands with herbicides is possible. Triclopyr and 3,6-dichloropicolinic acid were compared to 2,4,5-T on 9 crops at lethal and sublethal rates. Although the herbicides were phytotoxic to some crops at normal field rates, most caused little damage at sublethal rates that simulated spray drift. The greater tolerance of cotton to 3,6-dichloropicolinic acid than to 2,4,5-T or triclopyr may allow significant use of the herbicide near cotton.

Herbicide spacing and brush control - College Station, Texas. On rangeland weeds, huisache and live oak, various spacing treatments of tebuthiuron pellets up to a 2.7-m square grid had little effect on herbicide efficiency. On Macartney rose, spacing up to 2.7 m center had little influence on picloram effectiveness. Data therefore indicate that brush can be controlled with widely placed pellets that would be suitable for aerial application and would reduce exposure of desirable vegetation and the environment to the herbicide and lower control costs.

Use of the rope-wick herbicide applicator aids kleingrass establishment - College Station, Texas. Preliminary data indicate that use of the rope-wick applicator to apply glyphosate may have promise for reducing resistant grassy and broadleaf weeds that compete with seedling kleingrass. Kleingrass has relatively poor seedling vigor the first few weeks after planting and weed control is usually essential for its survival and establishment.

Allelopathic substances in tall fescue may be useful for controlling weeds - Columbia, Missouri. It was demonstrated that tall fescue inhibits germination and growth of large crabgrass, red clover and birdsfoot trefoil. Because allelopathic effects differed among genotypes of tall fescue, varieties with either high or low allelopathic properties might be developed. Allelopathy may explain why many fields of tall fescue are relatively weed free and why it is difficult to maintain stands of forage legumes in pastures containing tall fescue.

Absorption and metabolism of tebuthiuron by range plants related to selective control - Tucson, Arizona. The rangeland weed shrubs wait-a-minute bush, velvet mesquite and catclaw acacia, absorb and accumulate large amounts of tebuthiuron from the soil, but the range grasses, Rothrock grama, Arizona cottontop and Lehmann lovegrass, absorb and accumulate only small amounts. The grasses breakdown tebuthiuron rapidly, but the shrubs do not. This differential in absorption and metabolism is the primary basis for selective control of these shrubs in grasslands.

More lovegrasses established in tebuthiuron-treated than in root-plowed areas - Tucson, Arizona. Boer Lovegrass seedlings were established in greater numbers in areas in which creosotebush, tarbush and whitethorn acacia plants were killed two years prior to planting than in areas in which the shrubs were killed with a rootplow immediately prior to planting. This finding is important because it helps to explain the poor success in establishing grasses in creosotebush communities.

Control of ericameria, a shrub-type weed, with tebuthiuron - Temple, Texas. Ericameria is a native, shrub-type range weed that reduces forage production on portions of the 20,000,000 acres of rangeland in south Texas. Earlier research and ranchers' experiences showed that conventional brush and weed control practices are not effective against this troublesome shrub. However, renovation of Ericameria-infested areas is now possible through aerial application of the pelleted formulation of a new herbicide, tebuthiuron. Advantages of this treatment include the absence of herbicide drift associated with sprays, flexibility in timing of herbicide application, suppression of other undesirable brush plants growing with Ericameria, and substantial improvement in the productivity of these rangelands.

Economic evaluation of weed control options in western juniper woodlands - Reno, Nevada. Cost was compared among four alternatives for improvements on maturing western juniper (Juniperus occidentalis) woodlands. The alternatives were: a) the use of picloram to kill the trees with no further treatment, with a total cost of \$31 per acre (\$78 per ha); b) picloram with sufficient limbing and/or removal of trees to allow passage of a rangeland drill for seeding at a cost of \$179 per acre (\$448 per ha); c) mechanical clearing and burning of the trees at a cost of \$237 per acre (\$95 per ha); and d) wood harvesting and slash disposal at a cost of \$832 per acre (\$2,080 per ha). Based on equivalent energy values, the wood-harvesting and slash disposal operation would produce a profit for the landowner who could afford to invest labor. For a specific woodland, a combination of chemical and nonchemical treatments would be most cost effective.

Pilot testing of weed control, seeding, and grazing management technologies on degraded sagebrush rangeland - Reno, Nevada. The basic treatments for weed control and seeding on rangelands were physically established at the Gund Research and Development Ranch for the pilot testing program. The large-scale, 16 hectare treatment plots were established with field scale equipment, side by side, in a common potential environment. The soils, plant and animal communities, and watershed characteristics of the study area were enumerated before the treatments were applied and are being monitored during the treatment establishment period. Actual cost data were collected and a budget was prepared for all treatments. This pilot research and development program provides an unique opportunity to comparatively evaluate integrated pest management on rangelands in terms of cost effectiveness, biological efficiency, and environmental effects.

New direct planting methods without tillage for establishing legumes in stubbles of silage corn and small grain - Ithaca, New York. USDA scientists at Cornell University have developed methods for planting legumes by direct planting without tillage that result in establishment successes and yields equal to or greater than those obtained by conventional tillage. By applying appropriate herbicides at the proper time after harvest of silage corn or small grain, or

after killing of cover crops, and planting legumes with newly developed drills, establishment success probabilities with legumes exceeded 90%. These methods allow planting later into spring and earlier in mid- and late summer. This technology will increase crop yields, reduce tillage and energy requirements, improve water use efficiency, reduce soil erosion, reduce production costs, and increase net profits on farms.

Pastures and run out legume hay fields can be renovated by no-tillage means - Ithaca, New York. USDA researchers have developed technology for site programs involving integrated combinations of herbicides, fertilizers and planting equipment to establish birdsfoot trefoil and clovers in pastures and sods with very high success probabilities over the last five years. Because of technology developed by federal researchers at Cornell, the percentage of establishment successes for legumes in sod have nearly doubled in the last five years. The farmers now have economically feasible options for no-tillage planting of these legumes and should benefit considerably from reduced energy requirements, higher grazing capacities on pastures, lower costs, higher profits, and reduced erosion.

Alfalfa can be established in sods after solving the pest problems - Ithaca, New York, Through integrated pest management approaches USDA and Cornell researchers found that alfalfa could be established successfully in sod if the vegetation was controlled by herbicides and if a combination of molluscicide and insecticides was applied at planting. If the combination treatments can be made economically feasible, the incidence of successful no-tillage alfalfa establishment in sod would rise dramatically.

Yellow nutsedge propagation in summer and fall is now better understood - Ithaca, New York. USDA and Cornell researchers developed a scheme for controlling yellow nutsedge in mid-summer, late summer and early fall-planted crops geared to the time of the weed emergence and the subsequent formation of reproductive tubers. Best time for control after emergence shifts with declining day length and soil temperature. Proper timing of herbicide should result in best control of nutsedge and prevention of reproductive tuber formation.

Technological Objective 5: New and improved weed control technology for controlling, managing, or using weed populations to improve water quality, fish and wildlife habitats, and recreational areas in aquatic and noncropland sites.

#### Research Locations:

Albany, California	Gainesville, Florida
Davis, California	Stoneville, Mississippi
Fort Lauderdale, Florida	Prosser, Washington

#### Examples of Recent Progress:

Basic information should enhance the development of fluridone (a promising new aquatic herbicide) - Prosser, Washington. The distribution and fate of <sup>14</sup>C-labeled-fluridone were examined in submersed plants and hydrosoils, respectively. Fluridone was taken up by both the root and shoot tissues of the aquatic plants and was phytotoxic in extremely low concentrations. A small amount of the herbicide moved from the roots to the shoots, but movement in the opposite direction was negligible. Fluridone was fairly persistent in the hydrosoils (7-month half life) and was degraded to one polar metabolite. These results provide basic understanding of the action of fluridone, which is being developed for managing aquatic weeds in irrigation systems.

Intraspecific variation in reed canarygrass shows need for herbicide rotation - Prosser, Washington. The control of reed canarygrass, the most troublesome weed on irrigation ditchbanks in the Pacific Northwest, has been erratic when certain postemergence herbicides were applied. Studies conducted on 19 selections of reed canarygrass at a common site showed that many of the selections were morphologically different and that they responded differently to herbicide treatments. Thus, inherent differences within the population dictate that more than one herbicide must be registered for the control of this species on irrigation ditchbanks. The only method of controlling populations resistant to the registered herbicide is by mechanical means which require high energy and financial inputs (about \$430/mile/yr).

Mass-rearing of *Arzama densa*, a native insect moth, for possible manipulative augmentation for the biological control of waterhyacinth - Stoneville, Mississippi. Recent studies indicate that the insect *Arzama densa* can be reared on an artificial diet containing waterhyacinth extract. Other new techniques in rearing include use of shredded diet and cage mating in an environmentally controlled room. So far, 200,000 individuals have been reared during 5 consecutive laboratory generations. A total of 40,000 *Arzama densa* larvae were provided to the U.S. Army Waterways Experiment Station personnel, Vicksburg, Mississippi for a study of field efficacy against waterhyacinth at Norco, Louisiana.

New system developed for evaluating controlled release herbicides - Ft. Lauderdale, Florida. A prototype flowing-water system was developed for evaluating controlled release herbicide formulations (CRHF). In this cooperative program with the Army Corps of Engineers, a CRHF of 2,4-D was evaluated in static- and flowing water-bioassays. Analytical procedures for monitoring 2,4-D residues in water were developed and/or modified and refined. Rate of 2,4-D release from CRHF was greater than anticipated by a factor of 3. Phytotoxic 2,4-D concentration from CRHF was maintained in flowing water for 8 weeks and gave more effective control of aquatic weeds than conventional formulations of 2,4-D.

Aquatic weed sampling aids in hydrilla eradication decisions - Davis, California. Information on the extent and severity of *Hydrilla* infestation in the Imperial Irrigation District, El Centro, California, helped to provide a basis for evaluating success of on-going control and eradication operations. Results of sampling showed that methods of applying herbicides should be changed to increase effectiveness.

Plantings of aquatic weed competition may demonstrate new weed control practices  
- Davis, California. Several plantings of dwarf spikerush were made in canals  
and some have become established. If plantings continue to spread, this method  
could provide a practical tool for management of noxious aquatic vegetation.  
Planting techniques are being refined.

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National Research Program 20290

AGRICULTURAL CHEMICALS TECHNOLOGY FOR  
CROP PROTECTION AND MODIFICATION

This basic, multidisciplinary national research program emphasizes the development of new knowledge, new concepts, and new principles on the relationship of chemical structure to biological activity; including the nature, behavior, and fate of chemicals in soils; their mechanisms of entry, movement, activity, selectivity, metabolism, and fate in plants; their performance efficiency; and safety to crops, soils, and nontarget organisms in the environment. This research is essential to the efficient and safe use of pesticides and plant growth modifiers in the development of high-yielding food, feed, and fiber agro-ecosystems that will maintain the nation's food supply and improve the quality of the environment. This program supports the missions and goals of ARS, S&E and the Department. The intramural research program is organized into 23 projects at 10 locations and is conducted by 30 ARS scientists in cooperation with several Federal agencies, State agricultural experiment stations (SAES), private universities and research institutes, and industrial research organizations. This NRP also supports 5 cooperative extramural research projects by 5 SAES scientists in 3 states and 1 PL480 project by 3 foreign scientists in 1 foreign country. Progress in 1980 was reported in 50 scientific publications.

NPS Contact: W. C. Shaw

Technological Objective 1: New concepts and knowledge for improving the primary evaluation and structure-activity assessments for enhanced development of improved herbicides, fungicides, nematicides, insecticides, and growth regulators that are compatible with a quality environment.

Research Locations:

Berkeley, California	Frederick, Maryland
Peoria, Illinois	Raleigh, North Carolina
New Orleans, Louisiana	Fargo, North Dakota
Beltsville, Maryland	Philadelphia, Pennsylvania

Examples of Recent Progress:

Controlled-release oryzalin and oxadiazon extend weed control in container-grown ornamentals - New Orleans, Louisiana. Weed control for container-grown ornamental plants is costly because of the labor involved in conventional methods. Effectiveness of herbicide applications was extended by the use of controlled-release formulations. Oryzalin/alginate and oxadiazon/alginate beads (2.5 mm dia.) containing 2-3% active ingredient extended weed control from 7 weeks (with a conventional application) to 10 weeks. There was also evidence that longer weed control might result if antimicrobial chemicals were added to the formulation.

Rapid, direct analysis of dichlobenil in water - New Orleans, Louisiana. The herbicide dichlobenil in water is usually analyzed by gas chromatography after a time-consuming extraction. Water samples now can be directly analyzed by monitoring release of dichlobenil from controlled-release formulations. By use of UV detection, the method gives good accuracy and precision over the range of 0.1-15 ppm.

Strigol synthesis successful - New Orleans, Louisiana. The potent stimulator of witchweed seed germination strigol, was synthesized; 90 mg of pure strigol and 80 mg of pure epistriogol were prepared. The procedures of Sih and coworkers were modified at several steps of the synthesis to improve yield and purity of the products. These refinements make feasible the preparation of strigol and epistriogol in gram quantities - amounts critically needed to evaluate the germination stimulants for control of witchweed under field conditions.

Strigol and epistriogol separated by high-pressure liquid chromatography - New Orleans, Louisiana. The tedious column chromatographic procedures now required for the separation of the isomers, strigol and epistriogol, from reaction mixtures was replaced with a new reverse-phase, high-pressure liquid chromatographic (HPLC) procedure. Conditions have been discovered that permit analytical separation of strigol, epistriogol, and unidentified impurities by HPLC. Refinement of the separation procedures is underway and will permit the use of preparative-scale HPLC for resolution of strigol reaction mixtures, thus circumventing column-chromatography.

Growth regulator enhances herbicide penetration - Frederick, Maryland. The penetration of the nonsystemic herbicide, bentazon, was enhanced in test plants that had been pretreated with the growth regulator, gibberellin. The enhanced penetration was accompanied by the previously demonstrated increase in herbicidal effect. This research demonstrates that growth-regulator-induced plant modification can improve the effectiveness of herbicide treatment.

A new fly chemosterilant, J2644, can be used to control housefly population - Albany, California. J2644 was discovered and supplied to APHIS and used by that agency to regain control of huge housefly populations that had reached epidemic proportions in their Texas and Mexican screwworm-rearing facilities. These flies had become resistant to standard insecticides and had severely affected worker morale and the cost of operating these huge plants.

Mosquito growth regulators discovered that are highly effective at very low concentrations - Albany, California. Studies by USDA and university scientists at the University of California Mosquito Control Laboratory indicate that some of these growth regulators discovered by USDA scientists are highly promising at 0.02 ppm against California mosquito species and extensive field trials are planned for the summer.

Two analytical methods developed for the rapid, specific detection of hepatotoxic pyrrolizidine alkaloids - Albany, California. These methods are applicable for detection of these alkaloids at the low levels that might occur in food products such as milk, grains, honey and herbal remedies.

New safer nematicides undergoing evaluation - Beltsville, Maryland. One of a group of new active compounds (with relatively low mammalian toxicity) is highly active in the greenhouse, in preplant and in at plant soil drenches and in

preplant soil mixes, but almost inactive as postplant drenches around established infected plants (root-knot nematodes/tomato). These results show ability to contact and affect target nematodes in soil, and also, show need to improve root penetration by formulations research. Results are promising because relatively few nematicides are registered. Nematodes are difficult to control and it is difficult, also, to detect and develop relatively safe nematicides. If activity of this new chemical can be improved, it would be an important addition to the small stock of nematicides currently available to growers.

Biological activity followed computer predictions in studies of chemical structures versus biological activities of 49 substituted pyridazinones - Beltsville, Maryland. USDA and BASF scientists cooperated in applying computerized pattern recognition techniques in the analysis of biological activity data developed by USDA scientists. Based on these results, four new pyridazinones were synthesized, and their biological activity was cooperatively evaluated. One of the four new compounds had activity equal to or greater than the previously discovered pyridazinones.

New herbicides control weeds in many crops - Beltsville, Maryland. Eighty-one percent of the chemicals evaluated in the field in 1980 displayed significant herbicidal activity. Some chemicals seriously injured all but one or two crops; others allowed as many as ten crops to grow unharmed but adequately controlled weeds. In the list below the numbers following each crop name represent the number of new chemicals that satisfactorily controlled, pre- and post-emergence respectively, weeds in that crop: alfalfa 3,3; birdsfoot trefoil 3,4; buckwheat 2,1; cabbage 3,0; corn 9,2; cotton 7,6; cucumber 2,2; flax 5,3; peanuts 8,3; red clover 1,1; safflower 3,1; snapbeans 5,3; soybeans 5,3; sugarbeets 3,3; and tomatoes 0,1.

Potential competitiveness of perennial weeds in minimum tillage field crops - Beltsville, Maryland. Perennial weeds such as poison ivy, hemp dogbane, and field bindweed, that previously were a minor problem in conventionally cultivated corn and soybeans, are becoming a serious problem in some minimum-tillage corn and soybean fields in the Middle Atlantic States. Because of poison ivy growth some corn fields have been taken out of minimum tillage programs in some parts of Maryland. None of the currently registered preemergence herbicides will give satisfactory control of perennial weeds in corn and soybeans without crop injury. It is anticipated that perennial weeds may become serious competitors of corn and soybeans in continuous minimum tillage crop production.

Postemergence applications of new herbicides and controlled release formulations controlled selected turf and weed grass species - Beltsville, Maryland. Eight selected ornamental groundcovers were generally tolerant to two new herbicides at rates that controlled grasses. Controlled release formulations of profluralin and metolachlor were somewhat more herbicidal to a bioassay species over time than commercial non-control release formulations. A controlled release formulation of butylate was equivalent to a commercial formulation for control of Italian ryegrass in a greenhouse study. A field study comparing three controlled release formulations of trifluralin with a commercial formulation under droughty conditions revealed (1) higher grain yields and (2) lower weed counts in plots treated with commercial trifluralin.

Technical Objective 2:

New and improved knowledge of the nature, behavior, and fate of agricultural chemicals in soils that influence the performance of pesticides and growth modifying chemicals and their safety to crops, soils, and nontarget organisms in the environment.

Research Locations:

Beltsville, Maryland  
Stoneville, Mississippi

Examples of Recent Progress:

Spray drift of arsenical cotton herbicides onto rice and soybeans shown not dangerous - Stoneville, Mississippi. Although arsenical herbicides are extensively used in cotton, rice and soybeans are often grown nearby and research showed that label restrictions on allowed application times prevent significant crop damage or toxic residues of arsenic in rice and soybeans due to spray drift. Label violations (late-season applications), however, can cause damage and produce arsenic residues in the harvested grains.

Simple equation provides rough estimate of nonpoint source pesticide pollution of water - Stoneville, Mississippi. Based on an analysis of data from many locations, pesticide types, and weather patterns, a surprisingly simple equation was developed which should provide water-quality planners with estimates on where pesticide pollution potentials are greatest. Prediction is based only on pesticide types and amounts applied.

Low arsenite levels found on pressure treated wood surfaces - Beltsville, Maryland. Arsenical salts are one of the major wood preservatives used in this country. Some arsenic remains on the surface of the wood after treatment. The low levels of arsenite found on the surface of the treated wood indicate that little hazard should be expected from handling or sawing the treated wood. This fact will allow the continued registration of the salt-based wood preservatives.

Arsenite found in calcium and lead arsenate when mixed with certain adjuvants - Beltsville, Maryland. Lead and calcium arsenates were used for insect control in the past and have been alleged to cause toxic effects to exposed workers. Both arsenicals were formulated with lime, lime-sulfur, sulfur, and casein. The adjuvants caused a change from arsenate to arsenite. Thus, the arsenite may have caused the toxic effects and not arsenate. The two forms have different biological activities and the regulatory agencies must start distinguishing between them and the kinds of toxic effects they cause.

Suspended sediment reduces pesticides in the aquatic environment - Beltsville, Maryland. The addition of sediment to pesticide-equilibrated model aquatic environments reduced the amount of pesticide in solution and in aquatic organisms. Reductions were larger for the insecticide, dieldrin, than for the herbicide, diuron. These two pesticides were added to aquatic model ecosystems containing four species of organisms. At 2-week intervals, untreated sediment was added, and pesticide distribution between water and aquatic organisms was determined. This information improves our understanding of the fate and behavior of pesticides in the aquatic environment, may help explain field data, and improve pest control practices in aquatic sites.

Protocols developed for adsorption of toxic organic chemicals to soils - Beltsville, Maryland. Environmental testing required for pesticide registration is being expanded, in part, to many other toxic chemicals. Adsorption to soil is important because it affects both transport and transformation loss. Factors influencing sorption measurements are being tested, and results to date have led to recommendations for zero headspace, autoclaved soil, 1:5 soil:solution ratio, time-of-equilibration measurement, and three concentrations (minimum). Chemical degradation of one compound (aniline) was demonstrated.

**Technological Objective 3:** New and improved knowledge on the mechanisms of entry, movement, activity, selectivity, metabolism, and fate of applied pesticides and growth regulators in relation to their effective action in plants and their safety to subsequent crops and nontarget organisms.

**Research Locations:**

Beltsville, Maryland  
Raleigh, North Carolina  
Fargo, North Dakota

**Examples of Recent Progress:**

Improved control of leafy spurge with plant growth regulator-herbicide combinations - Fargo, North Dakota. Leafy spurge, a serious noxious weed, which infests some 3 million areas of pasture and rangeland across the central and western portions of the United States, causes economic losses estimated at \$10.5 million annually. Control of leafy spurge with conventional herbicide treatments is difficult, presumably because the applied herbicides fail to reach the extensive, perennial root system. Plant growth regulators, in conjunction with conventional herbicides, should increase the amount of applied herbicide that reaches the root system. In order to study such an interaction with leafy spurge, an effective system was developed that affords uniform plants of suitable size, and eliminates unwanted variability. All plants were vegetatively propagated (cloned) from a single individual leafy spurge plant. With this system basic physiological and biochemical studies of various combinations of growth-regulators and herbicides are possible and should optimize the transport of the applied herbicide to the root system, thereby improving the control of leafy spurge.

Plant growth regulator interactions as a basis for herbicide action in wild oat - Fargo, North Dakota. Wild oat is a major weed problem in U.S. small grain production. Previous studies have shown that a new herbicide diclofop methyl, that will kill wild oat, acts to kill grassy weeds by interfering with the action of the plant hormone, IAA. The ester form of the herbicide penetrates into the plant much faster and in greater quantities than the acid form. However, because of its chemical properties the ester form localizes and binds to different sites not necessarily involved with IAA action. The acid, however, being chemically more similar to IAA apparently localizes or binds to sites

specifically involved with IAA action. Therefore, the herbicide could be made more effective for control of wild oat at a lower application rate if its acid form could be introduced into the plant.

Increased basic knowledge of major agricultural chemical detoxication pathway in plants - Fargo, North Dakota. Glutathione conjugation is involved in the metabolism and/or selectivity of many leading classes of pesticides used for crop protection in U.S. agriculture. These classes of pesticides include the acetamide herbicides (propachlor, alachlor, etc.), the chloro-triazine herbicides (atrazine, propazine, etc.), the thiocarbamate herbicides (EPTC), the carbanilate herbicides (CIPC), the diphenyl ether herbicides (fluorodifen), certain fungicides (PCNB), and some of the organophosphorothioate insecticides (methidathion). Recent studies on the metabolism of the fungicide, pentachloronitrobenzene, represent the most detailed published account of the metabolism of a pesticide via glutathione conjugation. A great deal of new information was presented on the nature of intermediary and terminal metabolites, methods of metabolite isolation, metabolite derivatization, and the mass spectrometry of glutathione-related metabolites. This research has a broad impact on pesticide biochemistry in plants, animals and the environment.

New chromatographic techniques for surfactant analysis - Fargo, North Dakota. Ethoxylated, nonionic surfactants are significant components (20-30%) of all agricultural formulations with an estimated annual use of approximately 150 million pounds. There are several types of these surfactants and each may contain impurities. In the past, complete surfactant analysis required specialized chromatographic and spectrometric equipment. Recent research, however, has developed a reversed-phase, thin layer chromatographic (TLC) system that rapidly identifies major ethoxylated nonionic surfactant components and estimates contaminant materials. In addition, multiple surfactant samples are analyzed rapidly without costly instrumentation. Various pesticide formulating agents can now be checked for conformance to specifications or compared for batch-to-batch equivalence by this new semi-quantitative method. For more detailed analyses, this system can be combined with previously applied normal-phase TLC methods or specialized high pressure liquid chromatographic (HPLC) techniques.

Basic research on mechanisms of herbicide action provide clues to discovery of new herbicides and greater safety - Raleigh, North Carolina. Herbicides that uncouple photophosphorylation (chlorpropham, dinoseb, ioxynil, and propanil) were shown to inhibit the light-dependent fluorescent quenching of atebrin in isolated spinach thylakoids. The concentration at which inhibition occurred coincided with the molar concentrations required to stimulate photoinduced photosystem I electron transport. The results suggest that the herbicides dissipate the energized state across the thylakoid membranes and hence, reduce the driving force for phosphorylation. Herbicides such as chlorpropham, dinoseb, ioxynil, propanil, and perfluidone were shown previously to perturb organelle membranes. The herbicides increase proton permeability in lecithin liposomes, inhibit chloride transport in the inner mitochondrial membrane, and induce the efflux of potassium from intact spinach chloroplasts. Proton permeability induced by propanil and chlorpropham and the potassium permeability induced by all of the herbicides may be caused by non-specific perturbations that result from the partitioning of the herbicides into organelle membrane lipids. Herbicides (chlorpropham, dinoseb, ioxynil, and propanil) that interfere with phosphorylation and electron transport in mitochondria isolated from dark-grown legume hypocotyls act in the same way on mitochondria isolated from chlorophyll-containing foliar tissue.

Technological Objective 4: Develop new information on natural bioconstituents and related synthetic compounds that control physiological and biochemical processes for the development of chemicals to modify plant structure and processes.

Research Locations:

Peoria, Illinois  
Beltsville, Maryland

New Orleans, Louisiana  
Philadelphia, Pennsylvania

Examples of Recent Progress:

New plant growth regulators from fats and oils inhibit growth of suckers on tobacco - Philadelphia, Pennsylvania. Compounds that can be made from fatty acids, principal components in fats and oils, act as growth regulators. In laboratory assays, some of these compounds were 100% effective in inhibiting the growth of suckers on tobacco plants. The development of entirely new plant growth regulators through synthetic chemistry holds great promise for agriculture, since the new regulators might enhance or retard plant development in new ways. The potential for practical development is magnified by the ready availability of inexpensive starting compounds for synthesis, as is the case of transforming fatty acids into these potentially useful and valuable growth regulators.

Evaluation of Brassinolide, the plant growth promoter - Beltsville, Maryland. Two analogs of brassinolide, the plant growth promoter isolated from rape pollen, were prepared and evaluated in greenhouse and field studies. These biologically active brassinosteroids (BR) are tetrahydroxy-steroid lactones with a C-24 methyl group. The synthetic analog 2a, 3a, 22(B)-tetrahydroxy-24(B)-methyl-B-homo-7-oxa-5a-cholestane-6-one was evaluated in field studies for the second year. During the 1980 season, crop yields were 25% less on unfertilized than on fertilized plots, but this loss in yield was recovered when plants were repeatedly treated (at least 3 times) with 0.01 ppm of BR. BR treatment increased yield of lettuce, radishes and red beet from 8% to 54% depending upon the crop and field nutrition status. The eyes of Cobbler potato seedpieces were treated with BR and greened for 4 days before planting in a fertilized field. Treatment with BR increased yield over that of the controls by 21% in number and weight of marketable potatoes.

Basic research on growth regulators shows potential for increasing yields and quality of crops - Beltsville, Maryland. Two plant hormones, IAA and ABA, have opposing effects on sucrose uptake against its gradient in isolated root sink tissues of sugar beet. Uptake is inhibited by IAA but is usually stimulated by ABA. This and other aspects of hormonal physiology/biochemistry in sugar beets should lay the foundation for sophisticated studies on the use of plant growth regulators for controlling sugar beet growth and development, and, thereby increase crop productivity.

Technological Objective 5: Improved automated search, storage, and retrieval systems for relating chemical structure and biological activity of pesticides and growth regulators, including their nature, behavior, and fate in all aspects of the environment.

Research Locations:

Beltsville, Maryland  
Frederick, Maryland

Examples of Recent Progress:

Frederick chemical data base consolidated in the ARS computerized system - Frederick, Maryland. A comprehensive set of WLN-processing programs was developed for use on the Frederick terminals; the user instructions were revised in July-August 1980, and formed into a booklet. With these, the 30,500 chemical records can be rechecked and revised at Frederick at little or no cost.

Revise the WLN chemical structure descriptions in the 6,600 Mitchell records, then in the 30,500 Frederick records - Frederick, Maryland. Extensive effort was made in correcting computer lists of non-matching WLN records, and about 100 remain to be put into the on-line Mitchell master file. An equal number of WLN errors was discovered in the pilot file of 6,600 AWLN (advanced WLNL) records. Six on-line files of WLN and three of AWLN Mitchell records were used for editing and to gain experience for the 1981 revision of 30,500 Frederick records.

Manage chemical structure formula, and generic indexing information for the 6,600 chemicals tested for plant growth regulator activity at Beltsville by Dr. J. W. Mitchell - Frederick, Maryland. Checker programs were used to create Mitchell files in the same format as the Frederick records, with BATCH digits for molecular formulas. Biological-response data for all 6,600 Mitchell records were entered into the ARS Data Base by the FAMULUS program, and analysis of the biological activity groups in these records is in process. The Frederick Data Base tape is the only one available for biological data analysis on-line since termination of the computer-processing Task Force.

Publish the computerized information in the 30,500 Frederick records - Frederick, Maryland. An important small fraction of the Frederick file consists of inorganic compounds, ranging in complexity from simple binary salt types to quite a few polymolybdophosphate (phosphomolybdate) types. Revised WLN descriptions were prepared for these. On-line conversion of the 30,500 records is in process.

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PEST CONTROL EQUIPMENT AND METHODS

This program involves development of equipment and techniques to decrease production losses from crop pests, while minimizing requirements for fossil fuels and adverse effects upon the environment. The research is primarily of an engineering nature, but involves extensive cooperation with entomologists, pathologists, weed scientists, and other nonengineering disciplines.

NPS Contact: L. A. Liljedahl

Research Locations:

Gainesville, Florida  
Tifton, Georgia  
Beltsville, Maryland  
Stoneville, Mississippi  
Columbia, Missouri  
Wooster, Ohio  
College Station, Texas  
Yakima, Washington

Technological Objective 1: Develop equipment and techniques to increase the efficiency and safety of chemical pesticide applications.

Examples of Recent Progress:

Reduced pesticide dosage for mosquito control - Gainesville, Florida.  
When applied with aircraft, dilution of naled to 16% concentration in heavy aromatic naptha provided mosquito control of an application rate of 0.25 oz/Ac equal to control obtained with 1.5 oz/Ac application rate of undiluted naled. This finding may permit as much as a 6-fold reduction in use of naled for mosquito control.

New equipment developed for pest emergence weed control in soybeans - Columbia, Missouri. A new between-the-row recirculating sprayer was developed for postemergence weed control in soybeans, and was compared with drop-pipe directed applications, and over-the-top application. A special hooded sprayer was also developed. The best soybean yields were obtained when either the between-the-row recirculating, conventional shoes, cultivation, drop-pipe, or over-the-top applications were made for weed control. The yields for the hooded sprayer were less than yields for the other equipment. Best weed control was obtained with the between-the-row recirculating sprayer. The drop-pipes, shields, and broadcast applications had the poorest weed control.

Mechanical and pneumatic shields evaluated for reducing drift from ground sprayers - Columbia, Missouri. Results from tests indicated that drift deposits could be reduced by up to 60% under the most favorable conditions evaluated. At less than 4.8 km/hr ground speed the mechanical shield is not advantageous but drift reduction with this shield increased as ground speed increased. Results comparing a pneumatically shielded and a conventional boom did not indicate a consistent advantage in favor of the pneumatic shielded boom. The pneumatic shield may offer some advantage (25%) at slow ground speeds (3.2 - 4.8 km/hr).

Continuous rate-controlled row-crop sprayer developed - Columbia, Missouri. A new concept of row-crop sprayer operation was developed and tested in which spray concentrate was metered into one, or a small number of, mixing points in the spray boom at a rate proportional to travel speed. The automatic control system worked most satisfactorily when only one injection point and low pressure nozzles are used on the spray boom. The sprayer eliminates unused tank mix of pesticides, eliminates operator exposure occurring during tank mixing, and eliminates nonuniform pesticide application caused by variable travel speed.

Maximum control pesticide sprayer for tree crops developed - Wooster, Ohio. A new concept of orchard sprayer has been developed which simultaneously greatly reduces operation exposure to pesticide concentrate and enhances efficiency of pesticide application. In the new sprayer the pesticide is siphoned directly from the manufacturer's container, up to four separate pesticides are metered into a mixing point near the spray nozzles at a rate proportional to travel speed (with different rates for each pesticide), and the spray nozzles and air carrier jets surround the tree and are shielded from ambient winds. The pesticide concentrate containers as well as the sprayer pumps, pipes, and hoses are also flushed with clean water after use by operating a few special controls. The equipment eliminates leftover tank mix, reduces pesticide mix compatibility problems, eliminates operator handling of pesticide concentrate, eliminates nonuniform pesticide applications caused by variable travel speed, eliminates "blow-through" of spray in trees, and simplifies rinse-out of equipment after use.

Theoretical description of air flow of orchard air sprayer developed - Wooster, Ohio. A mathematical model of the orchard air sprayer was developed based on a new theory of turbulent fan jets. Air velocity fields predicted by the fan jet model agreed closely with measured air velocities produced by two commercial air sprayers. This sprayer model will be used to determine the effect of atmospheric advection and sprayer travel speed on the air velocity patterns of air sprayer jets. Because droplets are transported and deposited on fruit trees by the air jet, the understanding of the air sprayer jet offered by this model will aid improvement of the efficiency of sprayer applications of pest control agents.

Drift reduction from polymer spray additives not proportional to polymer concentration - College Station, Texas. A polymer spray additive intended to reduce drift was found to decrease the proportion of fine spray droplets (less than 100-um or micrometer diameter) when used at high concentration but to actually increase the proportion of fine spray when used at low concentrations. Thus, there must exist minimum concentrations which must be exceeded for use as drift reducing agents, and below which the polymer may act only as a surfactant.

Technical Objective 2: Develop equipment and techniques to increase effectiveness of nonchemical control of pests.

NPS Contact: L. A. Liljedahl

Research Locations:

Gainesville, Florida  
Tifton, Georgia  
W. Lafayette, Indiana  
Mississippi State, Mississippi  
Columbia, Missouri  
College Station, Texas  
Yakima, Washington

Examples of Recent Progress:

Audiometric detection of damaged flight muscles in mass-reared Mediterranean fruit flies - Gainesville, Florida. It has been reported that muscle damage occurs in the adult Mediterranean fruit flies as a result of mechanically separating the pupae from the rearing medium. In cooperation with the Fruit Fly Laboratory in Hawaii we have determined that the muscle damage alters the male calling sound. This muscle damage can easily be determined by recording and analyzing this calling sound. This new information will greatly aid the quality control program in the mass-rearing plants of the medfly.

Mating leks determine mating behavior of fruit flies - Gainesville, Florida. Comparative literature study, previous reports from other workers on the Mediterranean fruit fly, and recent observations on the Caribbean fruit fly demonstrate that "leks" are a feature of mating behavior of many pest insect species. Leks are places where male insects aggregate to perform mating displays and attract receptive females; they are common where mating does not occur directly on female oviposition sites and they are characterized by high levels of male-male competition and discriminating choice of mates by females. Biocontrol techniques which rely on behavioral manipulation (such as sterile insect releases) must take into account the many attributes and behaviors required of successful males in lekking species.

Prediction of sex pheromone dispersal patterns in the warehouse environment - Gainesville, Florida. A method has been developed to predict the way in which sex pheromone disperses from a trap in a warehouse. Currently, sex pheromones are being used as baits in traps to monitor pest insect populations. The new method helps determine the best places to put the traps and the optimal doses for the bait without the need for costly experiments.

New system reduces boll weevil rearing cost and eliminates brine disposal problems - Mississippi State, Mississippi. Equipment and a method were developed making it possible to reuse the old brine which is used in harvesting the boll weevil eggs from the diet pellets. The quantity of salt needed for brine making was reduced by 90% and the problem of disposing of large volumes of brine was eliminated. Overall, this will help reduce the cost for the mass-reared weevil.

Larger size oviposition cages for boll weevil save cost and handling time - Mississippi State, Mississippi. Oviposition cages up to four times the size of the present standard cage gave as good an egg production per female as the standard cage. Larger cages are more economical to fabricate per weevil capacity, and it would take very little more time to feed/service the weevils in larger cages than in smaller ones.

Economical systems for dispersal of sterile boll weevils in field - Mississippi State, Mississippi. A unit for dispersing sterile weevils over a cotton field was mounted on a trail bike type of motorcycle. The motorcycle was operated in the row middles between the cotton plants, and the dispersal units metered and dispersed the weevils to each side of the bike onto or around the plants. The initial cost of the complete outfit was low, operation cost was low, and the unit was adapted for small and large fields with or without trees and/or utility power lines through or around them. The method produced better knowledge and control of where the weevils were being placed within the field than that usually gained with aircraft equipment.

Practical aircraft-mounted equipment developed for large-scale distribution of eggs of parasitic wasps for insect control - College Station, Texas.

The experimental system previously developed for distribution of Trichogramma eggs was redesigned to increase hopper capacity, increase application rate, eliminate clogging due to host egg clumps, and incorporate a thermoelectric cooling system for prevention of parasite emergence before release.

The performance of the system has been evaluated in both laboratory and field<sub>3</sub> tests. No problems were experienced during three aerial releases of  $200 \times 10^3$  parasitized host eggs/ac on an 80 ac test field near Portland, Arkansas.

Technological Objective 3: Develop new and improved equipment and techniques for operational pest management systems.

NPS Contact: L. A. Liljedahl

Research Locations:

Gainesville, Florida  
W. Lafayette, Indiana  
College Station, Texas

Examples of Recent Progress:

Computer model developed for mosquito-malaria population growth - Gainesville, Florida. A basic computer model was developed to simulate the interaction between mosquito and human populations and malaria transmission. The malaria model is written in the FORTRAN computer language and can be used as a separate program with fixed inputs of mosquito population data or it can be used as a subroutine in conjunction with previously developed FORTRAN models of mosquito population dynamics. The model separates the development stages of the malaria parasite into 1-day increments within the body of a mosquito and a human. The recovery rate of an infected human is varied as a function of time after infection. The model was developed with as much flexibility as possible to allow changes in epidemiological and entomological parameters.

Excellent Heliothis trap-lure combination developed - College Station, Texas. Pheromone trap and lure combinations were developed for Heliothis zea and Heliothis virescens that are usable for both research and pest management applications. This survey tool has great potential for use in IPM decision-making. Reduction of early season male moth populations by pheromone trapping may have future potential.

MOTHZV continued to be used in the Texas Agricultural Extension Service Program - College Station, Texas. In 1979, approximately 5740 cotton producers in 91 counties used MOTHZV, a computerized model used for predicting bollworm and tobacco budworm populations in cotton, to help manage 4,069,300 acres of cotton and consequently realized an estimated net benefit of \$4,960,000. More recently, field and laboratory data from the literature were used to revise the eight coefficients in the MOTHZV model that are used to compute the effective number of predators from field estimates of beneficial insects. A series of simulations of various management strategies showed that crop damage could be kept below acceptable levels with chemical sprays alone or by natural beneficial insects in combination with augmentative releases of parasites. More than one early-season spray application was highly detrimental to natural predator populations. The number of spray applications or the number of augmentative releases of parasites could be cut in half by adjusting the timing of the spray applications or the augmentative releases.

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## Special Research Program

### INTEGRATED PEST MANAGEMENT SYSTEMS

Technological Objective 1: Combine two or more pest suppression methods into practical systems of integrated pest management (IPM) to reduce pest problems in crop production, animal production, marketing, and human health and safety.

NPS Contact: Waldemar Klassen

#### Research Locations:

Note: Scientists at various locations submit systems research proposals in order to compete for funding from the Administrator's IPM Systems Funds of \$1.1 million per year. Projects at the following locations are currently funded:

Fort Collins, Colorado  
Gainesville, Florida  
Tifton, Georgia  
W. Lafayette, Indiana  
Orono, Maine  
Stoneville, Mississippi  
Ithaca, New York  
Weslaco, Texas

#### Examples of Recent Progress:

IPMS-NER-80-1. Integrated systems for managing potato pests - Orono, Maine.  
FY 1980-1984. Contact: S. S. Leach, ARS.

This project was implemented in 1980. Funds were received late in the season, but some studies were begun to meet the objectives of the program.

Several cultivars were grown at two spacings each (6 in. and 12 in.) to determine the effect of variable plant canopies on yield, weed control, and microclimate. Spacing had little influence on yield, although two cultivars had greater yields at the 6 in. spacing than the 12. Specific gravity did not differ by cultivar or spacing. Weeds were not a significant problem in any plot, perhaps because the herbicide linuron was applied pre-emergence.

Some experiments have been conducted to identify techniques to incorporate plant resistance into potato for IPM purposes. The goal of the experiment is to determine the extent to which the predictive system "blitecast" can be modified to incorporate the effects of plant resistance. Relative resistance of various potato cultivars has been quantified in previous investigations. We have compared progress of potato late blight in small plots of susceptible (Hudson) and resistant (NY59) potatoes. Fungicide (mancozeb) has been applied every 7 days as dictated by blitecast modified to incorporate resistance.

The effect of plant resistance is greater than that of fungicide, as shown by the reduction in the amount of the latter. The results indicate that fungicide usage can be decreased quite significantly with the use of resistant cultivars. By using a forecast system modified to incorporate the effects of plant resistance, growers can use fungicides and fuel more efficiently than they do with the forecast alone or with a schedule of weekly fungicide applications only.

Laboratory studies have been conducted to determine the effects of the herbicides linuron, dinoseb, metribuzin, EPTC, paraquat, dalapon, and combinations of these on the five major soilborne pathogens of white potato: Rhizoctonia solani, Fusarium sp, Verticillium albo-atrum, Alternaria solani, and Heminithosporium solani.

Of the materials tested, only dinoseb prevents growth of all the organisms tested. The combination of dalapon and EPTC restricts growth of R. solani but not growth of the other fungi tested. All combinations with dinoseb restrict growth of the fungi significantly.

IPM-NER-80-3. IPM in no-tillage systems for forages and rotations involving forages - Ithaca, New York. FY 1980-1984. Contact: D. L. Linscott, ARS.

Recent studies have shown that even with satisfactory weed control, the proportion of successful stands of no-till alfalfa is far less than desired. Failures are characterized by uneven and poor emergence, and damage is particularly evident on sod sites within 30 days after seeding. We report here a number of field experiments that have been attempted to determine the major causes of these early seedling losses. Plots were seeded over the period June 2-4, with chemicals applied 1 to 2 days after seeding, except that methyl bromide (MeBr) was applied 6 to 8 days before seeding ( $1 \text{ kg}/22\text{m}^2$ ). Carbofuron and dyphonate were applied as sprays ( $1.1 \text{ kg}/\text{ha ai}$ ); diazinon as a powder ( $1.1 \text{ kg}/\text{ha ai}$ ); ridomil, a fungicide, as granules ( $2.2 \text{ kg}/\text{ha ai}$ ); and the molluscicides, mesurol and metaldehyde, as pellets ( $.95 \text{ kg}/\text{ha ai}$ ). These experiments have shown that application of mesurol significantly reduces seedling losses and the proportion of plants damaged and improves yield and average plant development. The response to mesurol and MeBr is greater on those sites where the soil has been recently disturbed by plowing (stubble, annual weeds) than on sod and quackgrass sites whereas the response to insecticides tends to be reversed. However, the response to the insecticides is less than the response to mesurol. It is also evident that plant response to a molluscicide combined with carbofuron is invariably greater than to either chemical applied alone; most of this additional response can be attributed to the molluscicide component. The fungicide is ineffective.

IPMS-NCR-80-1. An IPM system for crop production in the eastern corn belt region - Lafayette, Indiana. FY 1980-1984.

The project has been organized and implemented. However, no results can be reported at this early date.

IPMS-WR-80-1. Systems approach to IPM in irrigated crops - Fort Collins, Colorado. FY 1980-1984.

The project has been organized; and the fields are being monitored for insects, diseases, and nematodes. However, no results can be reported at this time.

IPMS-SR-80-1. IPM systems for horticultural crops - Weslaco, Texas.  
FY 1980-1983. Contact: C. M. Heald, ARS.

We are continuing the IPM program on nematode, weed, insect, and disease pests within a multi-cropping system that emphasizes vegetables and melons.

Data were collected on yield, quality, and nematode populations of R. reniformis and M. incognita in cantaloupe crops followed by sweet pepper crops during 1980. Yields of cantaloupe were primarily affected by the reniform nematode. Yields of cantaloupe from fumigated treatments were significantly higher. Interactions of treatment with reniform nematode populations or with yield were not significant.

Vegetable IPM studies indicate that the two species of dipterous leaf miners found on cantaloupe and peppers do not adversely affect crop yields. Pepper weevil damage as much as 60% of final pepper harvest. Decreased use of insecticides for leaf miner control seems justified. Other studies indicate that yellow opaque plastic traps are effective in monitoring leaf miners. Eight species of hymenopterous parasites attack leaf miners; they cannot control leaf miners but they do adversely affect parasitism. Large varieties of host plants also make miner control difficult.

Additional phases of the 4-yr intensive cropping rotation system continue as planned.

IPMS-SR-80-2. Maximizing pest control in soybeans through manipulation of management techniques - Stoneville, Mississippi, and Tifton, Georgia.  
FY 1980-1982. Contacts: C. G. McWorther and Ellis Hauser, ARS.

This research was started in 1980 to develop more efficient production systems for soybeans by maximizing control of diseases and weeds. Its primary emphasis is on biocontrol techniques (such as maximizing crop-weed competition), and its uses economic thresholds to determine minimum inputs of fungicides and herbicides. An intensive field study has been started with a split-, split-, split-plot experimental design. Whole plots include three levels of foliar disease control: (a) no control; (b) minimum disease control, with one application of benomyl at the early-pod stage and another 2 wk later; and (c) maximum foliar disease control, with benomyl applied at flowering and thereafter at 14-day intervals. Split plots involve management of weeds with four dates of weed removal: none, 2 wk, 4 wk, and 20 wk. Split-split plots are two levels of weed competition, no weeds and sicklepod. Split-split-split plots are soybean row spacings of 25, 50, and 100 cm.

The incidence of foliar diseases on soybeans in 1980 was very low, because the growing season was extremely hot and dry. Foliar applications of benomyl have no significant effect on soybean yields or seed weights, although the maximum

level of disease control increased soybean yields by about 10%. The three row spacings showed no effect on soybean yields or seed weights. Competition with sicklepod for 2 wk did not reduce soybean yields, but competition reduced yields by 5% in 4 wk and by 11% in 20 wk. Soybean seed from all plots were studied to determine incidence of disease and the effect of disease on weed control treatments on germination. None of the variables studied in the field affected germination of harvested seed. The three levels of disease control had no effect on the presence of Fusarium spp., Diaporth spp., Penicillium spp., or bacteria; but the presence of Alternaria spp. was increased with maximum usage of benomyl. The incidence of diseases on soybean seed was not influenced by presence or absence of weeds in individual plots nor by the period of weed competition in plots infested with weeds. At Tifton, Georgia, and Headland, Alabama, populations of beneficial insects were increased and those of pest insects were decreased when soybeans were left weedy. The quality of soybean seed harvested in all plots was very low. Seeds from soybeans grown in plots with 100-cm rows had lower conductivity values and reduced levels of infection with Diaporthe spp. than those from plots with 25- or 50-cm rows, indicating that soybeans produced on 100 cm rows were under greater drought stress than the others.

This study will be continued in 1981 and 1982. The unfortunate weather conditions of 1980 reduced the efficiency of this study; but if we continue it, we should be able to realistically show the interactions of various levels of weed competitions and weed control on soybean yields and seed quality. From these we can define minimum levels of pesticide input for maximum profits in soybean production.

IPMS-SR-80-3. An IPM system for dog fly and other filth-breeding flies - Gainesville, Florida. FY 1980-1984. Contact: R. S. Patterson, ARS.

Stable flies, Stomoxys calcitrans, are a serious nuisance to both humans and animals. Both adult sexes bite and suck blood, requiring at least one blood meal each day. They reduce milk production and weight gain, and they make animals difficult to manage. Stable flies migrate in north Florida from the farming areas more than 50 miles to the Gulf Coast. When the flies are present in the beach resort areas, they can cause a million dollar loss in revenue per day. Currently, the major means of control is aerial application of insecticides after the flies have reached intolerable levels.

This research is intended to evaluate whether integrating sanitation, attractant-toxicant devices (ATD), parasites, larvicides, etc., into an economically feasible IPM program at the breeding sources can suppress and even eliminate the adult fly problems in the beach resort areas 50-70 miles away.

Since this IPM study was activated in September 1980, Dr. Hogsette has been transferred to Panama City, Florida, and Dr. M. J. McGowan has been hired and stationed in Gainesville. Two technicians have been recently hired, and an entomologist has been assigned to the project. A house trailer has been refitted into a field laboratory in Chipley. The state of Florida has furnished laboratory and office space at the West Florida Arthropod Research Laboratory, Panama City. Projects are in progress to study stable fly populations over

time; to correlate population fluctuations with weather patterns; to survey natural parasites of fly pupae on dairy farms; and to develop the precipitin test for determination of stable fly hosts. Projects now underway and proposed for the summer of 1981 include migration studies with laboratory-reared and wild stable flies, determination of arthropod fauna in fly breeding media, evaluation of agricultural practices conducive to fly breeding, correlation of the digestion rate of blood meal with the time the meal is taken, correlation of blood meal volume with digestion and flight activity, and determination of whether stable flies use nectar as an energy source.

PRINCIPAL CONTACTS - SRP: IPM Systems

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## Special Research Program

### MINOR USE PESTICIDES

**Technological Objective:** Develop data for use in registration of pesticides for minor crops, minor uses on major crops, and speciality uses.

This Special Research Program is intended to improve availability of pesticides for minor and special uses by the agricultural community. It assures continuation of pesticides for crop and livestock production and for protection of commodities in storage, distribution, and marketing channels. These technologies can lower the cost of fruits, vegetables, and other agricultural commodities and increase the efficiency of their production by growers, small farmers, and homeowners. Entomologists, plant pathologists, weed scientists, chemists, and nematologists work in teams to develop the data required to register minor use pesticides.

NPS Contact: P. H. Schwartz

#### Research Locations:

Salinas, California  
Denver, Colorado  
Byron, Georgia  
Savannah, Georgia  
Tifton, Georgia  
Urbana, Illinois  
Vincennes, Indiana  
Beltsville, Maryland  
Frederick, Maryland  
Delaware, Ohio  
Wooster, Ohio  
Corvallis, Oregon  
Charleston, South Carolina  
Weslaco, Texas  
Logan, Utah  
Prosser, Washington  
Yakima, Washington  
Kearneysville, West Virginia

#### Examples of Recent Progress:

Significant progress made in developing data to support registrations of minor uses of pesticides - Nationwide. Scientists in the Agricultural Research Service (ARS) cooperated with 24 state scientists on 94 food-use requests and 773 ornamental-use requests during 1980. These projects were conducted at 18 locations in ARS. From this total, 53 food-use projects and 338 ornamental-use projects were completed in 1980. The IR-4 program currently has a backlog of about 600 food requests, and they are receiving 200 new researchable projects a year.

About 1066 ornamental requests have been assembled into data packages by the IR-4 staff. Thus far, 1096 registrations have been developed for ornamentals. There are 1605 priority 1 and 2 projects yet to be researched.

Three petitions were assembled by ARS and submitted to IR-4 - Beltsville, MD, Honolulu, HI.

- a. The use of gamma radiation to control insects on raw agricultural commodities.
- b. The use of malathion and methyl eugenol to control the Oriental fruit fly.
- c. The use of alfalfa looper virus on cabbage and lettuce.

ARS assembled a petition to establish an exemption from the requirement of a tolerance on all raw agricultural commodities for CO<sub>2</sub>, N<sub>2</sub>, and combustion gas products. The petition was established as a final rule by EPA in November 17, 1980.

#### PUBLICATIONS

See appropriate NRP Listings.

## SPECIAL RESEARCH PROGRAM

### PILOT TESTING OF ALTERNATIVE METHODS FOR PEST CONTROL

The purpose of this Special Research Program is to secure the development and commercial use of methods of pest management that tend not to produce adverse environmental impacts and that are essentially safe for people. For example, the new technology must be free of the problems that attend use of many of the broad-spectrum insecticides, such as hazards to humans, biomagnification, and toxicity to nontarget species. To a limited extent, this Program includes systems research includes optimization of the use of conventional pesticides.

#### Technological Objective:

The objective is to rapidly advance newly emerging technology toward implementation in order to (1) reduce net losses from pests; (2) to reduce the impacts of pest control technology on the environment, either by improving current technology or by developing new technology; and (3) to reduce the hazard to humans of pest control technology.

NPS Contact: Waldemar Klassen

#### Research Locations:

Note: Scientists at various locations submit pilot research proposals for alternative methods in order to compete for funding from the Administrator's Pilot Testing Fund of \$1.67 million per year. Projects currently are funded at the following locations:

Stuttgart, Arizona	Reno, Nevada
Davis, California	Los Cruces, New Mexico
Shafter, California	Ithaca, New York
Fort Collins, Colorado	University Park, Pennsylvania
Gainesville, Florida	Florence, South Carolina
Tifton, Georgia	College Station, Texas
Manhattan, Kansas	Lubbock, Texas
Beltsville, Maryland	Weslaco, Texas
Starkville, Mississippi	Prosser, Washington
Stoneville, Mississippi	Yakima, Washington
Columbia, Missouri	Madison, Wisconsin
Oxford, North Carolina	St. Croix Island, Virgin Islands

NER-81-1 - Evaluation of integrated pest management (IPM) systems for winter wheat in actual farm situations of the Northeastern Region, University Park, Pennsylvania. About 2 million acres of small grains are grown in the northeast region of the United States each year. The annual farm value of this grain production from wheat, oats, barley, and rye is nearly \$120 million. In the northeast region small grains are often poorly managed, low-priority crops that have received inadequate research attention. At present, economical returns from these crops are marginal because of nonintensive cultural practices and losses caused by pests and environmental stresses. Current production problems with small grain crops have generated many research activities. This pilot test program is particularly concerned with determining optimum yields of small grains through control of foliar diseases, soil-borne pathogens, and environmental stresses and with the use of best-known cultural practices. Field plots

have been established on growers farms to test some of these ideas on increasing yield.

The northeast region is an area with a deficit in feed and food grain. If current yield-limiting factors in the region can be controlled, small grain production can be increased enormously. The Center for Cereal Research has been established at the Pennsylvania State University since 1979 to enhance research efforts for improving the small grain production in the Northeast. Recent research at the Center and advances made in Europe under similar climate conditions, show that a two-fold improvement in small grain yields is possible.

Contact: H. Marshal

NER-78-1 - The feasibility of management of golden-nematode population densities by integration of control technologies - Ithaca, New York. Management systems that include nematode resistance, non-hosts, and minimal nematicide usage have been developed to manage golden nematode densities in areas where spread is unlikely. This advancement is important to the Golden Nematode Quarantine Regulatory Program. Such systems can also be used on land infested with golden nematode to decrease densities and limit spread. Such systems may prevent establishment of the golden nematode on non-infested land if spread does occur.

Studies are being conducted on alternative management systems, suited for growers of both table stock and seed potato, that may keep golden nematode densities below spread level. After 2 yr of an alternative management system, monocultures of a resistant cultivar have reduced the nematode density 92%. After 3 yr the golden nematode density in suspected infested areas has not reached detectable levels with this system.

Contact: B. Brodie

NER-78-2 - Suppression of weeds by enhancement of the competitiveness of forages in minimum-tillage systems - Ithaca, New York. Legumes that have been planted with direct planting or no-tillage methods have been established successfully and have given yields equal to or greater than those from conventional tillage. Success probabilities exceed 90% with use of appropriate herbicides and proper time of application after silage, corn, or small grain are harvested or after cover crops are killed and crops are planted and with newly developed drills. The methods allow planting later into spring and earlier in mid- and late summer. These findings can greatly facilitate conservation of energy on the farm and conservation of soil resources, at less overall cost to the farmer.

Site programs have been established that integrate combinations of herbicides, fertilizers, and planting equipment to establish birdsfoot trefoil and clovers in pastures and sods with very high success probabilities. Because of this new technology the percentage of establishment successes in sod has nearly doubled in the last 5 yr. The farmers now have economically feasible options for no-tillage planting of these legumes and can benefit considerably from reduced energy requirements.

Alfalfa can be established successfully in sod if the vegetation is controlled by herbicides and if a combination of molluscicide and insecticides is applied at planting. If the combination treatments can be made economically feasible, the incidence of successful no-tillage alfalfa establishments in sod may rise dramatically.

Contact: D. L. Linscott

NER-78-3 - Avoidance of white rot in onions - Beltsville, Maryland. Three years of research in onion production fields have shown that a practical system for forecasting white rot is possible and can be implemented at any time. In the pilot test the population of the pathogens in the soil at the time of planting has shown good correlation with disease severity at harvest. The methods developed in this project provide a disease forecasting system to advise growers on planting fall-planted onions in a particular field. Such a forecasting system allows fields that are normally planted to crops in the onion family to be left unplanted to prevent losses; or, if they are needed for planting, they can be treated by chemical or biological means at the proper time.

Contact: P. Adams

NER-78-4 - Suppression of face flies with traps - Beltsville, Maryland. The face fly is found primarily on the faces of cattle and horses, where it feeds on secretions of the eyes and nostrils. Besides annoying animals and thereby interfering with normal grazing activities, the face fly is a mechanical vector of Moraxell bovis, the organism responsible for bovine pinkeye. It is a true vector for several species of eye worms. The face fly has been in the United States since 1953. There are currently no satisfactory control measures for it, even though this species is quite susceptible to many approved insecticides. Reasons for this include the difficulty of applying insecticides to the faces of animals and the migratory habits of the fly. Two habits of the face fly, however, make control possible. They oviposit in fresh cow manure, where the larvae develop; and adult face flies are attracted to white painted plywood traps.

#### Objectives:

The objectives of this work are: (1) to determine whether the traps provide control of the flies in pastures without insecticide; (2) to determine whether the traps can eliminate adult face flies that immigrate into pastures with cattle under insecticide treatment or flies that survive exposure to the insecticide; and (3) to demonstrate the efficacy of a feed-through insecticide when used on all farms in a wide area.

Face fly populations were monitored in four areas of Howard County, Maryland, in 1978, 1979, and 1980. The following treatments were imposed: (1) white sticky traps were placed in all pastures containing cattle; (2) stirofos was fed to all cattle, either in the concentrate portion of the ration or in a self-fed mineral block; (3) these two treatments were used together; and (4) no treatments to control face flies were used, as a check. Some modifications were made between 1979 and 1980.

Face flies on survey traps were counted in all 3 yr. Counts of face flies were expressed as an index of face fly activity by dividing weekly 1979 and 1980 counts by weekly 1978 counts. The index was used to adjust for inherent differences in fly populations among the areas. In 1979 these index values for the trapped area and the stirofos area were not significantly lower than the value for the check area, although the value for the combination area was. In 1980 index values for both the trapped area and the stirofos area were significantly lower than that of the check area, and the value for the combination area was lower than those of either individual areas.

Counts of face flies on the faces of cows were expressed as the number of weeks that averages more than 10 flies per base. These counts for 1979 and 1980, respectively for the different areas were: traps 8, 7; stirofos 5, 1; combination 11, 1; check 6, 10.

Contact: R. W. Miller

NER-77-4 - Feasibility of us of N-substituted alkyl amides and amines to manage plant parasitic nematodes - Beltsville, Maryland. Nematicidal activity has been discovered in a group of secondary and tertiary alkyl amines, many of which are highly active; but exploitation of this discovery has been hampered because technical and standard formulations of these compounds are rapidly inactivated and/or degraded in agricultural soils. Their potential as nematicides is high, because they are relatively safe and non-threatening to environmental safety and to vertebrate animals. Thus, if they can be adapted for practical field use, they may serve as urgently needed alternatives to other nematicides that have already been removed, or may be removed, from registration because of environmental safety requirements.

NNDD (N,N-dimethyl dodecanamine), one of the most active nematicides in this group, has been formulated in controlled-release (C-R) polymer, cast into film, and then ground into flakes. Early tests have indicated problems related to unsatisfactory control of particle size. We now report a method for producing NNDD in C-R polymer discs that can be size-controlled within a narrow range, a bioassay of these formulations, an analytic method to monitor NNDD loss/retention levels in these discs.

In tests with Panagrellus redivivus discs with an original concentration of 82 ppm killed 80 percent or higher of all nematodes over four 48-h test cycles.

Contact: J. Feldmesser

NER-77-3 Development of dwarf apple orchards for decreased use of pesticides - Beltsville, Maryland. The research on dwarf orchards is conducted at four locations: Beltsville Agricultural Research Center, Beltsville; New York State Agricultural Experimental Station, Geneva; Agricultural Experimental Station of Massachusetts, Belchertown; and the Fruit Tree Research Station of the Pennsylvania State University, Biglerville. The experiments have tested the lowest amount of pesticides that can be used on small trees, the economy of such orchards, the quality of fruit, and human exposure to pesticides. The orchards have been planned to allow comparisons of the effects on varieties and rootstocks from the wide ecological and climate range of the four locations. All four orchards are planted. The Beltsville orchard is considerably ahead of the others and is the only orchard old enough for research. Ultra-low volume spray at one-quarter of the recommended chemical per acre has successfully protected the orchard from apple scab and aphids.

Contact: M. Faust

NCR-81-1 - Development of practical methods for application of Bacillus thuringiensis (B.t.) to stored grain and oilseeds for moth control - Manhattan, Kansas. The purpose of this pilot study is to develop practical techniques for

applying B.t. dust and wettable powder (WP) formulations to grains, peanuts, and soybeans stored on farm and in commercial warehouses for control of lepidopterous storage pests.

Objectives:

The objectives are to develop methods for uniform application of B.t. formulations to surface grain and to ascertain effectiveness of the dust and WP formulations for control of the Indian meal moth and the almond moth.

Progress:

Laboratory tests have made to compare the effectiveness of dust and WP formulations of B.t. for protection of inshell peanuts from infestations of Indian meal moth and almond moth. The dust has been superior to the WP in all tests, with Dipel controlling both species at a dose of 31.25 mg/kg nuts for bulk treatment and at 50 mg/kg for 50-cm-deep surface layer treatment. The dust also protects both inshell and loose-shell nuts from significant insect damage. The WP does not provide complete insect control, even at a dose of 625 mg/kg, it is less effective as a surface-layer treatment and permits significant damage to loose shell nuts.

Formal cooperation was established with 32 farmers in Nebraska, Kansas, and Oklahoma to treat wheat and corn with B.t. during 1980. This study includes grain stored in 77 bins in the three-state area. To determine whether spray volumes can be reduced from the currently recommended rate of 7.5 gal/100 bu without sacrificing efficacy, we tested the WP formulation with both auger and rake-in applications and water volumes of 3 and 1 gal/100 bu. The dust formulation was tested with auger and rake-in application and also with aeration fans to pull dust across the grain surface. The treated bins have been sampled to evaluate the uniformity and toxicity of the bacterial deposits. The bins are being monitored to evaluate long-term performance of the treatment methods. Conclusive data are not yet available; however, the following field experiences may be described:

1. Treatment of the last 4 in. of grain as it is augered into the bin does not work as well as expected. If the grain is to be leveled, which is recommended for effective sampling and insect control, it must be leveled twice, both before and after threatening the last 4 in. of grain. When the surface is not leveled, the treated grain does not form an even layer over the surface cone of the grain mass. Also, grain spreaders do not adequately spread the treated grain over the surface, particularly in full bins and when higher water volumes are used.
2. The use of 1.33 gal of water per 500 ft<sup>2</sup> of surface apparently does not provide adequate coverage when applied as a rake-in treatment.
3. Water volumes higher than 3 gal/100 bu that is applied as grain is augered into bins may in some cases create excessive friction in the auger, slow the grain flow rate, and result in higher dosages. The auger may even become clogged with wet grain and be damaged. Thus, the label rate of 7.5 gal/100 bu may be excessive for auger application.
4. Achieving adequate depth of incorporation around the perimeter of bins has been difficult with use of rake-in applications in full or nearly full

bins. Thus, it may not be possible to fill bins completed if B. t. is to be effectively applied after bins are filled.

5. Farmers want more emphasis to be placed on evaluating the effectiveness of B.t. as a remedial treatment after moderate to heavy infestations are apparent. The sporadic nature of moth infestations and the uncertainty of storage times do not always encourage preventive treatment of grain.

Contact: W. H. McGaughey

NCR-80-1 - Development of a new concept in grain and food-product insect control that combines physical, chemical, and biological agents - Madison, Wisconsin.  
The purpose of the research is to develop systems combining physical, chemical, and biological control methods for an insect pest complex in a stored grain ecosystem.

Objectives:

The objective was to combine systems methodologies effectively to detect and control storage insects, concentrating on insect trap design and placement and on improvement of trap efficacy with food attractants and sex pheromones. Insect control agents such as chemical pesticides, oils, insect hormones, and insect pathogens may be incorporated in the trap design or may be used separately in the ecosystem for integrated control of target pests.

Progress:

Vegetable oils (cottonseed, soybean, corn, and peanut) have been used to suppress Sitophilus granarius (L.) in wheat grain. Insect progenies significantly decrease at dosage of 5 ml/kg. Oils at 10 ml/kg either kill the test insects or prevent progeny development; it is effective for not less than 60 days. Vegetable oils also agitate adult weevils to the extent that they migrate and fall into pitfall traps located in the grain. Oils may also help to reduce the amount of grain dust in a storage and thereby decrease the hazard of grain dust explosion.

Bioassays show that volatile components of wheat germ oil are responsible for initiating the aggregating activity of Trogoderma glabrum larvae. Synthetic octanoic acid is an active aggregating stimulant for Trogoderma glabrum larvae at some dilutions in mineral oil. Synthetic cis-3-hexenal, octanal, and gamma-octalactone also induce aggregation when tested alone or in combination.

An inexpensive perforated-probe trap for grain insects has been improved and is being evaluated with several insects and grain hosts. The trap may be used either with attractants, repellents, or pheromones. Insect trapping studies in food warehouses have confirmed the high efficiency of pheromone-baited folded-cardboard traps in catching male Trogoderma. Traps that are oriented easterly outside walls and corners, especially those near doors, produce the greatest catches of target insects. This may relate to morning brightness at doors and bays, attracting insects during their peak activity periods. Trogoderma catches are highest during periods of hot, dry weather.

Contact: W. Burkholder

NCR-77-2 - Feasibility of decreasing frost damage to crops by alteration of epiphytic bacterial populations - Madison, Wisconsin. We have used field conditions to show the potential for decreasing frost damage to crops such as beans, corn, and tomatoes by decreasing populations of selected bacteria on leaves. These bacteria, usually Pseudomonas sp., act as ice-nucleating agents associated with the ice formation in plants that results in crop damage. Removal or inactivation of these bacteria can result in an additional protection of 3-5° which may prevent ice formation. Bacteria can be inactivated by chemicals, but we are also investigating the possibility of developing antagonistic bacteria that are normal leaf residents. An important phase of this study is the improvement of our understanding of the epidemiology of resident bacteria on plant leaves and their relationship to ice formation. These studies have been expanded to include citrus, a high-value crop that may be subjected to frost damage at intervals.

Contact: C. D. Upper

SR-81-1 - The potential of an IPM scheme to control house flies and other filth-breeding flies at poultry farms, with special emphasis on the use of the parasitic wasp Spalangia endius - Gainesville, Florida. House flies and related flies breed in tremendous numbers in poultry manure; they are an annoyance and potential health hazard to humans and animals. The local health authorities continually urge farmers to control the flies. Unfortunately, current control practices are not efficient and many times are not effective. For one reason these flies, particularly house flies, can rapidly develop resistance if subjected to severe selective pressure from chemicals. Likewise, extensive use of pesticides can result in environmental contamination. Therefore, we must explore alternative methods of IPM control using the best attributes of existing and new fly-control techniques.

Objective:

The main objective is to incorporate Spalangia endius into an economically sound IPM scheme for controlling flies, mainly at poultry facilities but also at other types of farm and agricultural complexes. The main emphasis is on sanitation, drainage, baits, and release of parasites.

Progress:

This pilot study was funded in October 1980. Since that time the 36 square mile area in Charlton County, Georgia, has been surveyed and mapped for fly breeding. Dr. Gary Propp has recently (April 15, 1981) been hired to assist in this study. Six caged layer installations house about a quarter million birds; two broiler operations have 40,000 birds; and two inactive farms have facilities for about 100,000 birds. There are about 200 head of cattle and swine in the area. A packing house maintains some animals prior to slaughter, thus creating a suitable fly-breeding habitat.

The fly populations at the cage-layer operations are monitored weekly to correlate them with weather patterns and manure management practices. Seasonal fluctuations of populations of natural parasites and predators in the area are also being surveyed.

A Staphylinidae beetle, Creophilus maxillosus, and an unidentified Histeridae beetle have been collected in the test area, and colonies have been established in the laboratory. The life history of these beetles is being studied. Bait studies have been conducted with very promising results at two of the caged layer operations. More studies are planned for this fly season. Because Spalangia endius is apparently not indigenous to this area (it probably was eliminated by the excessive use of pesticides in the past), studies are being started to determine how quickly it can reestablish itself once it is reintroduced and if it can spread to other farms. The massive releases of the parasite S. endius will not start until next summer.

Contact: P. B. Morgan

SR-80-1 - Management of insect pests of in-shell peanuts with pheromones and insect growth regulators (IGR) - Gainesville, Florida. This pilot test is a 3-yr program to develop and evaluate pest management systems that prevent peanut deterioration during storage, with the systems excluding the use of classical insecticides. The pilot test is designed to show the extent that IGR and insect sex pheromones complement each other in the control of insects that damage stored peanuts.

Objectives:

The main objectives are to demonstrate pest management systems for control of insect pests in stored peanuts and to assay how IGR's and sex pheromones, individually and in combination, may be used to control the two major insect pests of stored peanuts, the almond moth and the Indian meal moth.

Progress:

Peanuts in lots of 1200 lb were treated with the IGR Methoprene, at either 4, 10, or 25 ppm. Each treatment was replicated four times. Additionally, three lots of peanuts of similar weight remained untreated. Each peanut lot was placed in an 8-ft<sup>3</sup> room, and the floor of each room was covered with peanuts to a depth of about 12 inches. Peanuts in two of the four Methoprene-treated replicates were in rooms whose air space was treated with vapors of the almond moth pheromone (Z,E)-9, 12-tetradecadien-1-ol acetate. After 9 mo. of storage, the total number of adult moths found in rooms with peanuts treated with Methoprene and pheromone was lower than the numbers from rooms treated only with Methoprene. The count in rooms containing peanuts treated similarly but headspace of the room infused with pheromone was 5500, 500, 475, and 100. Percent of damaged peanuts found in the Methoprene-treated lots (0, 4, 10, or 25 ppm) was 11, 9, 6.25, and 6.5 and, in those infused with pheromone, 14.5, 5, 5.75, and 6.5. Bioassays of pheromone concentrations in the storage rooms indicated a single pheromone treatment lasted about 8 mo. Methoprene concentration on peanut hulls declined about 50% over a period of 10 mo. However, residue on the peanuts increased slightly over the course of the experiment. Immediately after treatment (all dosages) the amount of Methoprene recovered from the peanuts was 0.05 ppm; after 10 mo. whole peanuts treated at 4, 10, or 25 ppm had Methoprene residue on kernels of 0.05, 0.21, and 0.62 ppm.

Contact: K. W. Vick

SR-80-3 - Biological control of three weeds in rice, soybeans, and cotton with fungal disease combinations - Stuttgart, Arkansas. The objective is to manipulate three mycoherbicides (Colletotrichum gloeosporioides f. sp. aeschynomene, C. gloeosporioides f. sp. jussiaeae, and C. malvarum) in weed management systems for control of northern jointvetch, winged waterprimrose, and prickly sida in rice, soybeans, and cotton.

Progress:

The biological and technological feasibility of using endemic plant pathogens as mycoherbicides was shown with three fungi on three weeds: Colletotrichum gloeosporioides f. sp. aeschynomene (CGA) on northern jointvetch, C. gloeosporioides f. sp. jussiaeae (CGJ) on winged waterprimrose, and C. malvarum (CM) on prickly sida. Biocontrol of northern jointvetch with CGA in 22 rice fields (579 acres) and 7 soybean fields (167 acres) was 86-99% when a suspension of 2 million spores/ml of water was applied aerially at 94 L/ha. Fresh spores controlled weeds better than suspended dry formulations, but control averaged 90% or more with both formulations. Tank mixtures of CGA, CGJ, and CM spores controlled northern jointvetch and winged waterprimrose on two rice fields (48 acres) without apparent synergism, antagonism, or "cross protection": prickly sida was not controlled. In a soybean field (5 acres) ground applications of a tank mixture of CGA and CM controlled northern jointvetch but failed to show any activity on prickly sida; northern jointvetch slowly developed disease symptoms and required about 3 mo. for the pathogen to kill it. Dry weather delayed symptom development, and irrigations were required for the pathogen to develop on the weed.

In Arkansas, prickly sida was controlled in small field plots when CM was applied in September (1980) after temperatures cooled, but it was not controlled when applied in June or July with high temperatures. These results suggest that environment, especially temperature, is critical to efficacy of CM on prickly sida; temperatures of 20-28°C favor activity of CM on prickly sida. CM, formulated as granules of vermiculite with mycelia and conidia and applied pre-emergence, has failed to control prickly sida in small field plots at Stoneville, MS.

Several species of Aeschynomene were compared for susceptibility to CGA. A. virginica was killed by CGA; A. americana, A. brasiliiana, A. falcata, A. histrix, A. paniculata, and A. villosa were immune; A. evenia, A. indica, A. pratensis, A. rudis, A. sensitiva, A. scabra were slightly susceptible to CGA.

In small plots tank mixtures of CGA and CGJ failed to control northern jointvetch and winged waterprimrose; lack of control was attributed to dry, hot weather after application of the fungi. A standard treatment of 2,4,5-T applied at mid-season controlled 100% of both weeds. Conventional herbicide treatments of propanil + bentazon followed by midseason 2,4,5-T, controlled northern jointvetch better than propanil + bentazon followed by midseason CGA; both treatments controlled winged waterprimrose. Insecticide (carbofuran or Amaze) or fungicide (benlate or fentil hydroxide) standard treatments did not affect the activity of CGA or CGJ on northern jointvetch or winged waterprimrose. Conventional applications of propanil + thiobencarb followed by midseason CGA and CGJ treatments gave best overall control of the weed complex (northern jointvetch, winged waterprimrose, redstem, and ducksalad).

Contact: R. J. Smith

SR-80-5 - Evaluation of cotton cultivars with resistance to bollworms, Heliothis zea (Boddie), tobacco budworms, H. virescens (F.), and boll weevils, Anthonomus grandis Boheman, under several insecticide regimes in the Southeast - Florence, South Carolina. We propose to develop and evaluate an improved method for the production of cotton in the Southeast. This IPM method involves three insecticide regimes and insect-resistant cultivars. Data show that these insect-resistant cultivars probably require less insecticide or fewer applications than present commercial varieties.

The Pee Dee germplasm pool includes an as yet unidentified source of resistance to Heliothis spp. that generally reduces square damage and live larvae by half. Identification of the causal agent(s) would help in the development of resistant cultivars and the management of insect pests. High gossypol, frego bract, and earliness are plant characters that contribute resistance to Heliothis spp. and boll weevils. The nectariless and glabrous traits, alone or in combination, aid Heliothis spp. resistance under low levels of infestation, but they are not considered in this study.

The objective of this pilot test is to determine if PD 695, PD 875, and PD 869, with resistance to Heliothis spp., can produce yields comparable to or greater than those of PD 6520, McNair 220, or Coker 310 if applications of insecticides are reduced.

The reaction of six cultivars is being tested under three insecticide regimes. The cultivars are (a) Pee Dee 695, a Heliothis-resistant, frego-bracted, early line; (b) Pee Dee 875, a Heliothis-resistant, normal bracted, full-season line; (c) Pee Dee 8619, a Heliothis-resistant, normal-bracted, full-season line; (d) Pee Dee 6520, a very early line; (e) McNair 220, an early cultivar; and (f) Coker 310, a full season check cultivar.

Cultivars are being compared under these three insecticide regimes: (a) a high rate of synthetic pyrethroid, applied every 3 to 7 days throughout the season; (b) a low rate with the same application schedule; and (c) a high rate of synthetic pyrethroid, applied as needed to control insects. Applications are based on economic thresholds for Pee Dee 695. Preliminary results with Pee Dee 695 in our small test plots indicate adequate control of Heliothis spp. with low rates or fewer applications, which suggests that production costs and insecticide load in the environment can be reduced.

#### Progress:

Three breeding lines, PD 695, PD 875, and PD 8619, with resistance to Heliothis spp., were compared in 1980 with a very early breeding line, PD 6520, and mid- and full-season check cultivars, McNair 220 and Coker 310, for lint yield and insect responses under three insecticide regimes. In the untreated plots, square damage and live larvae on PD 695 averaged about one half that on other cultivars, and these data agreed with those in earlier reports. However, we have usually found fewer larvae and less square damage on PD 875 and PD 8619. Lint yield losses in the untreated control suggest that only the very early breeding line PD 6520 escaped some damage from Heliothis spp. A preponderance of squares on PD 6520 and PD 875 during early season, on PD 8619 during late season, and on PD 695 throughout the season, suggests that the prolificacy of

these breeding lines influences their apparent resistance to Heliothis spp. Less square damage and fewer Heliothis spp. larvae on PD 695 also suggest some type of antibiosis. Unfortunately, the present PD breeding lines with resistance to Heliothis spp. are more susceptible than commercial cultivars to unfavorable growing conditions and fail to produce equal yields in some years, even when insects are controlled. Nevertheless, we believe we have a source of resistance that can be used to control Heliothis spp. on cotton.

Contact: R. F. Moore

SR-80-7 - Control of container-breeding mosquitoes in New Orleans by integrated use of predaceous *Toxorhynchites* larvae and standard insecticidal control methods - Gainesville, Florida. The peridomestic mosquito, Aedes aegypti, which breeds in artificial containers such as discarded tires and cans, is a major pest problem and potential vector of dengue in the Southeastern U.S. Dengue has been moving rapidly through Central America; in 1980 it entered the U.S. in Texas, causing concern among public health organizations in that area of the South infested with Ae. aegypti. Control of this species is difficult because the cost of reduction of the source is prohibitively high and recurring and because all but aerial adulticide applications are ineffective in most urban areas.

Objective:

The purpose of this test is to determine the practicality of Toxorhynchites as a biological control agent of Ae. aegypti, integrated with conventional control techniques.

Progress:

During the first year of this 3-yr pilot test program, the New Orleans study area was characterized for types and density of breeding sites and estimated daily number of biting Aedes aegypti females (10 to 50 per block). Toxorhynchites rutilus rutilus and its prey were continuously produced in the laboratory throughout the season. Several experimental releases showed that Tx. r. rutilus in the adult stage dispersed reasonably well within the release block but less readily between city blocks. Oviposition by released Tx. r. rutilus in ground containers of the type that produced Ae. aegypti was meager compared to expectations based on previous observations in sylvan habitats. Detailed studies of the ovipositional behavior indicated that Tx. r. rutilus decidedly preferred sites above ground level in spite of a greater abundance of potential oviposition sites on the ground. These behavioral characteristics cast doubt on the effectiveness of Tx. r. rutilus in the control of container-breeding mosquitoes in urban areas. However, preliminary field studies with Tx. amboinensis and Tx. brevipalpis in New Orleans indicate that these species are likely to oviposit in ground-level containers. Both species are easily mass-reared and thus are potential candidates to replace or complement Tx. r. rutilus. During the second year of the pilot test these two species will be evaluated in depth.

Contact: D. A. Dame

SR-78-1 - Management of tobacco budworms with hybrid sterility - St. Croix, Virgin Islands. The tobacco budworm, Heliothis virescens, is an economical pest

of several crops, including cotton, soybean, tobacco, and pigeon pea. This pest has developed resistance to most classes of insecticides. This resistance and environmental considerations have necessitated the search for alternative controls. The discovery of inherited sterility in backcross male hybrids has led to one such possibility. *H. subflexa* females crossed with *H. virescens* males give female hybrids that are fertile when backcrossed to *H. virescens* males and male hybrids that are sterile. This sterility persists generation after generation. The purpose of this pilot test is to determine whether native populations of tobacco budworms can be suppressed by infusing sterility into them through release of backcross insects. Success with such a program may lead to increased research into the use of hybrid sterility in control of other lepidopterous insects.

Progress:

Progress from 1978-1980 indicated that backcross insects reared at Stoneville, MS, and released on St. Croix interacted well with native insects with little selective mating. Also, interaction between the two insect types is more nearly random when backcross pupae are placed in release cages in the field and allowed to emerge than when adults are released from laboratory facilities. Further, these studies show that male sterility can be introduced into the native population by releasing backcross insects and that this sterility persists for at least five generations.

From November 1 to December 19, 1979, adults from a total of 10,000 pupae/day were allowed to emerge at 10 release sites (ca. 1000/site/day) in western St. Croix. At release sites the ratios of released to native adult males were 6.4, 4.5, and 9.6:1 as determined by males collected in cone traps, singly on host plants, and in copula, respectively. In cone traps located in western St. Croix at some distance from release sites, the ratio was nearly 1:1. In contrast, for traps located in central and eastern St. Croix, native males outnumbered release males by 3:1 and 12:1, respectively.

During January 1980, nearly 50% of the field-reared males collected in traps located in western St. Croix were backcross males. Only 18 and 12% of males collected in traps located in central and eastern St. Croix, respectively, were backcross. After three generations, the backcross frequency became homogeneous throughout St. Croix, with 39% of the trapped males being backcross.

From August 27 to December 17, 1980, nearly 40,000 pupae per day were placed in 50 emergence cages located throughout St. Croix (ca. 800/cage/day). From September 17 to February 25, 1981, the frequency of backcross males increased curvilinearly. For the last 2 wk of January and all of February 1981, 94.3 + 6.24% of the males trapped per week were backcross. There was no significant difference because of location.

The budworm population on St. Croix is still being monitored to determine whether sufficient sterility has been introduced to obtain suppression. Backcrossing at 95% is only a ratio of 19 backcross to 1 purebred *virescens*. Ratios of 30:1 or greater may be needed to show rapid decline in native populations. Researchers on this project think that such ratios could have been attained if releases had continued for one more month.

Contact: F. I. Proshold

SR-78-2. Development of integrated management of corn earworm and fall armyworm on sweet corn with semiochemicals - Gainesville, Florida. Pheromonal communication in the corn earworm was reduced by 90 to 100% for 22 days in small plots of field corn through use of an oxidation-stabilized formulation of (Z)-11-hexadecenal prepared by Conrel. This far exceeds the longevity of previous hollow-fiber formulations of this compound. About 70 acres of sweet corn were aerially treated with Conrel fibers containing (Z)-9-tetradecen-1-ol formate (Z9TDF for corn earworm) and (Z)-9-tetradecen-1-ol acetate (for fall armyworm). Damage counts and trap catches indicated that the treatments did not reduce larval infestations and plant damage levels because most of the fibers were deposited on the ground when the corn was small. In a subsequent experiment in a 30-acre field of corn, mating and oviposition by the fall armyworm were reduced 86 and 84%, respectively. These results are highly significant because (1) only one pheromone component was needed to reduce mating and oviposition in the fall armyworm and (2) the result was obtained in a relatively small field surrounded by other corn. Mating by the corn earworm was reduced by ca. 50% in a similar field treated with Z9TDF. These results show that this technique can be adopted by agriculture and industry as soon as formulations suitable for application of these compounds can be marketed.

Contact: E. R. Mitchell

SR-78-3 - Protection of tobacco by augmentation and conservation of natural enemies of tobacco budworm, tobacco hornworm, and aphids - Oxford, North Carolina. Up to eight applications of insecticides are made on tobacco each year, primarily to control budworms and hornworms. Most of the materials are highly toxic to beneficial arthropods and to other non-target organisms including humans, and the frequency of application represents a considerable use of energy.

The objectives of this pilot test are to develop ecologically acceptable methods to control tobacco insects that (1) minimize losses to insects; (2) minimize the use of toxic and persistent chemicals; (3) increase the use of specific insecticides harmless to non-target organisms; and (4) assess the feasibility of mass rearing and release of natural enemies.

Progress:

Up to 3,000 spined stilt bugs, Jalysus wichami=spinosis, per acre were released in ca. 150 A comprised of 4 groups of 10 fields each in Bladen County, North Carolina (Group I). Bacillus thuringiensis (B.t.) was used as needed for budworms and hornworms, and pirimicarb was used for aphids (1979 and 1980 only). These materials are specific for these pests and harmless to beneficials. Pests and beneficials were monitored weekly and their abundance was compared with those of Group II in which B. t. and pirimicarb were used as needed. For Group III conventional insecticides only were used as needed; and in Group IV choice or frequency of insecticide use was not restricted.

Budworm thresholds (levels of infestation justifying treatment) and number of insecticide treatments consistently dropped from 1978 to 1980. Hornworm thresholds and numbers of treatments also decreased, although Group III had relatively high thresholds and the highest number of treatments in 1978.

Blacklight trap catches of tobacco hornworm moths were three times more numerous in 1980 than in 1979 and catches of tomato hornworm moths were five times more numerous. Stilt bug counts, as expected, were highest in Group I fields and lowest in Group III fields. However, most of the Group IV stilt bugs were in the northeastern area, where insecticides were used sparingly early in the season and where the proportion of overwintering areas for stilt bugs relative to tobacco acreage was much higher than that in other areas in the county.

Data from the first 3 yr in this Pilot Test show that budworm and hornworm infestations have been lowest in the fields where stilt bugs are active and that stilt bugs plus other beneficials can virtually eliminate the need for insecticide treatments if pest populations pressure is low. It is also encouraging that the stilt bug can overwinter in the test area if it is not decimated by broad-spectrum insecticides. This would preclude release each year, particularly if other natural enemies were active early enough to supplement control of early-season budworms. Parasites of both budworms and hornworms have shown significant increases and, with an abundance of stilt bugs and other predators, may minimize the need for insecticide treatments. Reduction of insect pests in isolated or wide areas may be greater than these data show, because there all tobacco is under the influence of abundant natural enemies and specific insecticides; under these conditions the influence of migrant moths is greatly reduced.

Contact: A.H. Baumhover

SR-78-5 - Evaluation of early-maturing, nectariless, frego bract, and other resistant cottons in various combinations on cotton production in the mid-South - Mississippi State and Stoneville, Mississippi. This report covers research conducted at three locations by researchers from the Mississippi State location in the third and final year of this test. Complementary research on the same strains at three additional locations has been conducted by W. R. Meredith from the Stoneville, Mississippi, location.

We originally began the 3-yr project with eight pairs of nectaried-nectariless cotton strains. The okraleaf, frego bract, high gossypol, and DES-24 strains were dropped from the test for the final year. DES-24 has been replaced by DES-56, a commercial cultivar available to growers. The other three strains require a few more years of improvement as cultivars before they can be used for commercial production. The greatest interest in okraleaf development comes from areas where boll rots are a major problem.

The four pairs of cultivars used in the 1980 tests were: DPL-61, DPL-7146N; ST 213, ST 825N; Coker 420, Coker 420N; and DES-56, DES-56-N. These cultivars are presently available or have a high probability of being available commercially in the near future. We realize the need for agronomic improvements through continuing research on okraleaf, frego bract, and high gossypol; each of the genotypes has desirable traits for host-plant resistance. We are addressing these problems in other phases of our research.

The greatest number of Heliothis eggs was found on the Stoneville type (ST 213 and ST 825 pair) and the fewest on the Coker type at the three locations, with

the difference between these two types being significant at two locations. The Coker type received significantly fewer eggs than any cultivar type at one location. The Coker type also received significantly fewer worm-damaged squares at two locations. At one location significantly more lygus immatures were found on the DES-56 type than the other cultivar types.

Yields of nectariless and nectaried plants did not differ significantly at any location when averaged over the four cultivar types. Yield of lint per acre for the eight strains at each location were 776 pounds, 699 pounds, and 595 pounds.

Averaging the nectariless and nectaried lines over the four cultivar types gave us a measure of the value of nectariless. Significantly fewer Heliothis larvae were found on nectariless at one location and significantly fewer (50% Tess) lygus immatures were found on nectariless at two locations.

Considering nectariless for each of the four pairs of cultivars, DES-56 nectariless received fewer worms and worm-damaged squares than DES-56 nectaried at one location. Nectariless types from all pairs except Coker had significantly fewer lygus immatures than nectaried types. One location had high levels of lygus, and fewer plants with terminal squares missing were present in DPL nectariless and ST 825 nectariless at this location. Loss of terminal squares indicated damage by lygus immatures.

D-Vac samples were collected for 2 wk at one location in the plots before any insecticides were applied. Pest insects collected were lygus, whiteflies, fleahoppers, and leafhoppers. Predators were lady beetles, Nabis, Geocoris, Chrysopa, Orius, and spiders. Nectariless cotton strains, showed no major effects on predators or on leafhoppers. Lygus and fleahoppers at this location were not present in numbers large enough for an adequate measure. In DPL nectariless lady beetles were increased and Geocoris were decreased significantly. ST 825 nectariless showed an increase in Orius.

Contact: Johnie N. Jenkins

SR-78-5 - Evaluation of effects from various combinations of early maturing, nectariless, frego bract, and other resistance traits in cottons on cotton production in the mid-South - Stoneville, Mississippi. This report covers research conducted in the Mississippi Delta under this project.

The 1980 season was the third and final year of the pilot study. In all three years two insect regimes were used: a) no early-season insect control, and b) early-season insect control. Early-season insect control (early to mid-June) was aldicarb at 1 lb a.i./acre, with occasional early sprayings with dicrotophos or monocrotophos. The objective of these treatments was to create an early-season environment that allowed comparisons of the influence of early-season insects and Heliothis from nectaried and nectariless cotton. The major early-season insect pest was tarnished plant bug. Heliothis numbers were minimal throughout the testing period. In 1978, seven nectaried and nectariless pairs of varieties were tested; in 1979, nine pairs; and in 1980, four pairs. There were five, five, and six replications used in the 1978, 1979, and 1980 seasons, respectively.

### Progress:

The average yields of the early-season control and no control regimes were 905 and 757 lb/acre of lint, respectively. Early-season insects therefore decreased yield by 148 lb/acre of lint, or by 16.4%. The interaction of insecticide regime and nectaried varieties was significant for yield in all years. The average yield over all years for nectaried and nectariless varieties grown with early-season control regime was 919 and 890 lb/acre of lint, respectively. The average yield of nectaried and nectariless varieties grown without early-season insecticide was 726 and 789 lb/acre of lint, respectively. Early-season insects thus decreased yield of nectaried varieties by 21% and of nectariless by 11.3%. Expressed in another way, nectariless cottons yield losses were about one-half those of nectaried cottons. However, the percentage reduction in numbers of plant bugs collected on nectaried and nectariless cottons was about the same.

### Conclusions:

1. The pilot study did not accomplish all its objectives. One major objective was to test the influence of early-maturing cottons on late season build-up of Heliothis. Because Heliothis numbers and damage were minimal in all nine Delta tests, we could not test this hypothesis.
2. The results of this pilot study indicate that early-season insects can reduce cotton yields by at least 16.4%. These losses are much greater than the entomological community currently recognizes.
3. The major conclusion reached has been that nectariless cottons reduce plant bug numbers and yield losses from them by about 45%. In insect-free environments yields and quality of nectariless cottons are about the same as those of nectaried cottons. Therefore, nectariless cottons can make a major contribution to reducing insect losses and pesticide use. These reductions should simultaneously result in greater cotton productivity and economic returns and in an improved environment.

Accelerated breeding and development of nectariless cottons should be encouraged.

Contact: W. R. Meredith, Jr.

SR-78-7 - Crop rotation in management of nematodes, diseases, and weeds in multiple cropping and minimum tillage systems. - Tifton, Georgia. Intensive cropping systems are becoming commonplace in the Southeast as growers attempt to make more efficient use of land and farming equipment. In these pilot tests the effects of new and improved pest management systems are studied for control of nematodes, insects, diseases, and weeds in intensive cropping rotations. The effects of various tillage methods on pest control and crop production are also being investigated. Cropping systems include crops that are currently grown in the area and for which there is a market demand. Broad-spectrum soil fumigants applied to an intensive cropping system involving turnips, field corn, and southern peas have not been economically feasible under current prices and protection technology. However, the use of such soil fumigants greatly reduces the risk of damage from nematodes, weeds, soil-borne fungi, and insects. Results to date indicate no significant changes in nematode population densities due to tillage practice, row pattern, or cropping sequence. Numbers of nematodes have not increased to economic thresholds in these cropping sequence.

Contact: A. W. Johnson

SR-77-4 - Management program for citrus mealybug on citrus in the Rio Grande Valley of Texas - Weslaco, Texas. Ants have been found to interfere with and disrupt the regulatory capabilities of the citrus mealybug's natural enemy complex. Significantly higher mealybug population densities prevail if ants are not controlled; therefore, an effective integrated control program must consider ant control measures. Diazinon, the only registered pesticide available for ant control in citrus, has been found to be effective for 2 mo. Diazinon treatment requires repeated applications throughout the year for control of ants.

The introduction and release of parasitoids that attack the citrus mealybug in Texas have resulted in the colonization of Leptomastidea abnormis and establishment of Anagrus pseudococcii. The latter has become at times the dominant parasitoid in the citrus mealybug's natural enemy complex in Texas. The parasitoid complex has increased from three species recorded in 1977 to five species in 1980, which is a significant contribution to the development of a successful integrated control program for the citrus mealybug. The existing natural enemy complex of this mealybug, if not disrupted by certain toxic pesticides, can regulate the mealybug's population density to keep it below a level of economic injury. This results in a significant reduction in the use of pesticides and provides a savings in labor, energy, and cost of material as well as a reduction in the accumulation of environmental pollutants.

Contact: W. G. Hart.

SR-78-12 - Biological control of silverleaf nightshade by a foliar nematode parasite. - Lubbock, Texas. We have demonstrated that the nematode Nothanguina phyllobia can be used to control the weed silverleaf nightshade. In a test on uncultivated land, the nematodes reduced the plant mass of the weed by 23% and plant density by 42%. A 10 lb/acre inoculum rate resulted in 60% infection of silverleaf nightshade plants during the second year of growth. The inoculum was prepared from infected leaves and contained 50,000 larvae/g of leaf tissue. The biology of the nematode, including temperature and pH effects, has been investigated to determine potential use of the nematode for weed control.

Contact: C. C. Orr

WR-78-1 - Areawide aphid control in orchards and drainage ditches - Yakima, Washington. The objective of the pilot program has been to suppress the population of the green peach aphid (GPA) as they overwinter in the Yakima Valley before viruliferous aphids move into cultivated crops (e.g., sugarbeets) during the growing season. Two major overwintering areas have been recognized--the floors of orchards and drainage ditches. At each of these sites, the weed species serve as the hosts of the GPA. In the first year, the phenology of the key weed species of the GPA was studied in the orchards and drainage ditches. Studies in subsequent years have emphasized the replacement of the broadleaf weed hosts with grass (non-host of the GPA). Herbicide screening tests have been conducted and grass-cover plots have been established in drainage ditches and in peach orchards. This pilot study has improved our knowledge of the ecological interactions of aphids, weeds, and virus reservoirs; from this knowledge we can successfully develop methods and technology for the suppression of GPA for the protection of sugarbeets against beet western yellow virus.

Contact: G. Tamaki

WR-80-2 Impact from management of cover crops, weeds, and pesticides on the ecology and regulation of citrus thrips--Riverside, California. Twelve plots were established in a Valencia orange grove with annual weeds under furrow and sprinkler irrigation and with a solid ground cover of bermudagrass under sprinkler irrigation. Two plots under furrow irrigation were maintained 100% weed-free. The accumulated numbers of citrus thrip adult-days did not differ significantly between plots, except for those from established annuals under furrow irrigation that were periodically sprayed with paraquat. Thrips-day trends suggested that trees in established weeds, annuals, and bermudagrass contained larger numbers of immatures than those in newly established ones. Carbofuran, fonofos, chlorpyrifos, and FMC 35001 applied to the soil and to organic debris beneath citrus tree canopies provided effective control of thrips for 4-5 wk.

Contact: D. Moreno

WR-75-1 Weed control systems for irrigated agriculture - Fort Collins, Colorado. After five cropping seasons, the greatest depletion in the total number of weed seeds occurred in continuous corn plots. The overall decline in the total number of weeds per acre for both management systems averaged 93%. Plots that had been treated with herbicides for six consecutive years were devoid of weeds in July 1980. In both management systems in which herbicides had been discontinued after three consecutive years (1977) the average number of weeds per acre was 32,160.

Contact: E. E. Schweitzer

WR-79-1 - Biological control of aquatic weeds with plant competitors - Davis, California. Spikerush plantings have been made in seven canal sites, and additional studies have been started to investigate germinating weed seed displacement and effect of light quality and temperature. Two plantings appear successful.

Contact: L. W. J. Anderson

WR-78-2 - Root-knot nematode control with resistant alfalfa in rotation - Reno, Nevada - An alfalfa line, Nevada Synthetic XX, has been developed with resistance to root-knot nematode. The soil population of root-knot nematode has dropped from an initial value of 0.2 larvae/g of soil to a final value of 0.1 larvae/g of soil in a 1-yr-old planting of a resistant alfalfa. This decrease compares to an increase in a nematode population from 2.3 to 4.7 larvae/g of soil in a 1-yr-old planting of susceptible alfalfa. Tomato plants have been grown in fields previously planted to resistant or susceptible alfalfa varieties for 1 yr, root-knot indices are 50% lower in tomato plants from resistance fields. Thus, a nematode-resistant alfalfa can be used in a rotation system to significantly decrease the numbers of root-knot nematodes present.

Contact: G. D. Griffin

WR-77-2 - A comprehensive study of rehabilitated range ecosystems in the Southwest - Las Cruces, New Mexico. Plant production was measured for the fifth and final year on a 3,634-ha study site that received the first of two

applications of 2,4,5-T in 1975 and on a 3,318-ha control area. During the fourth season after treatment perennial grass production on sprayed and control area was 413 and 426 kg/ha, respectively. Production on the control area increased from the low levels of previous years, because the control area received 36 and 49 mm more precipitation than did the sprayed area in the third and fourth season, respectively. The plots infested with mixed creosotebush and tarbush and aerially treated with 0.4 and 1.2 kg/ha of picloram granules in 1978 had root kills of 12% and 14%, respectively; plots treated with 0.3, 0.4, and 1.3 kg/ha of tebuthiuron had kills of 37%, 88%, and 98%, respectively. These data suggest that 0.6+ and 0.4 kg/ha active ingredient of tebuthiuron pellets effectively controls on areas infested with honey mesquite and a mixed stand of creosotebush and tarbush, respectively.

Populations of rodents, birds, insects, and soil microorganisms have been compared on sprayed and non-sprayed mesquite dunelands. Completion of studies on microbial activity reveal that it is greater on dunes than on interdune areas regardless of treatment. Mean daily  $\text{CO}_2$  evolution from dune and interdune soil has been 2105 and 1708 mg  $\text{CO}_2$  per  $\text{m}^2$ , respectively. Mean daiy dehydrogenase activity of dune and interdune soil is 7.5 and 2.3 ug formazan formed per g dry soil, respectively. Microbial numbers in sprayed and non-sprayed areas have not been different as detected with dilution plate counts or the most-probable-numbers methods. Carbon dioxide evolution from unsprayed soil has been greater than that from sprayed soils on 4 of 15 sampling dates, indicating that 2,4,5-T may have had some effect on carbon flow within the soil system. Mesquite leaf tiers (Lepidoptera) are more abundant on sprayed mesquite areas than on non-sprayed areas. Seasonal activity of tenebrionid beetles in mesquite sanddunes has been studied. Bird censuses were conducted on sprayed and non-sprayed areas from June to August. Data from small mammal trapping censuses have been partially analysed. To date, 1,655 mammals representing 12 rodent and 2 leporid species have been noted. Early results indicate an average species richness of 3.76 and 3.67 species per area for the non-sprayed and sprayed areas, respectively. About 500 of the animals captured have been autopsied, and organs have been preserved for further analysis.

Contact: C. Herbel





